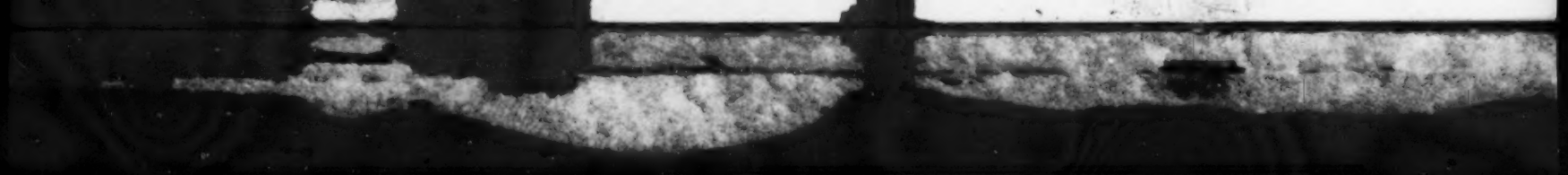

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ORIGINAL PAPERS

SOME OBSERVATIONS ON HEAT TRANSFER IN FURNACES[1]

BY D. J. MCSWINEY

ABSTRACT

Some of the phenomena of heat transfer in glass furnaces are reviewed; it is suggested that circulation of the hot non-luminous products of combustion may be an important factor in heat transfer in furnaces, and evidence is given as to the existence and the rapidity of this circulation.

Introduction

It is a rather general belief that heat transfer in medium high temperature furnaces, such as a bottle or flat glass furnace, is effected almost entirely through radiation. Some of the phenomena of glass furnace operation cannot be thus fully or readily explained. As the problem of improving furnace operation is most often thought to be that of increasing radiation, it may be of interest to point out some of these phenomena.

Differences in Furnaces

Soda lime furnaces are operated between 2300 and 2600°F, the average temperature of the glass surface being about 2500°F. Continuous tank furnaces are all heated by flames flowing through them and above the bath. The furnaces show wide variation in (1) the character of the fuel used, (2) the number of points by which the fuel enters, (3) the size of the flames, (4) direction of flame flow relative to the bath and

[1] Received September 20, 1926.

to the walls of the furnace, (5) the size and shape of the combustion chamber, etc. Furnaces differ widely in their overall thermal efficiency, but considering their wide variations it is surprising how little is the actual variation in their efficiency of heat transfer.[1]

Flame Temperatures and Heat Capacities

As the speed of heat transfer from the flame to a furnace increases with increase in the temperature of the flame, it is often stated that the best fuel is that which gives the highest flame temperature. This is not necessarily the case, for the flame temperature depends not only on the character of the fuel, but also on the rate of combustion.

Speed of Combustion

Above a certain point rapid combustion is not desirable because of its destructive cutting action on the ports, walls, and crown of the furnace, especially as the majority of glass furnaces are equipped with only a short or no port tongue.

The maximum rate of combustion of any fuel is attained only when the fuel is intimately premixed with air. Intimate premixing never obtains in commercial furnaces, hence the maximum rate of combustion and consequently the maximum temperature of any fuel is never attained in practice.

Heat Transfer a Function of Heat Capacity of Flame

From a purely thermal standpoint, the efficiency of heat transfer in furnaces from flames of high temperature but of low heat capacity may be less than that from flames of lower temperature but of higher heat capacity. The specific heat of a hot body not only determines the amount of heat it will give up for a definite drop in temperature, but, in flames of equal radiating power, the specific heat largely determines the rate of temperature drop, and consequently the average temperature and radiating rate during an interval of time.

Only a small portion of the heat given up by the flame is evolved at or near the maximum temperature for the available heat of the flame is being set free at a constantly decreasing rate from the point of maximum temperature to the temperature at which the waste gas leaves the furnace.

While it may be an important factor to the amount of its available heat and to the rate of heat transference, flame temperature does not appear to be essential to efficiency in heat transference. In practice many flames of relatively low temperatures will give up to the furnace most of their available heat. The heating power of and the maximum

[1] The efficiency of heat transfer referring to the degree to which the available heat of the flame is transferred to the walls and bath.

temperature attainable with the average producer gas are relatively low, yet such a gas with 50% excess air will often hold a tank at operating temperature without excessive waste gas temperatures.

In heat transfer by radiation, the radiating efficiency of the bodies is as important as the absolute temperatures or the temperature differential; the radiating efficiency may vary from that of a black body to zero, and would appear to be very low in the case of many flames.

Radiation and Luminosity

The radiating power of a flame is dependent to a very considerable extent on the more or less intangible property of luminescence. The luminosity of commercial flames varies greatly from the highly luminous or powdered coal flame to a producer or natural gas flame which under some methods of operating can be almost non-luminous. The completeness of heat transfer from these various flames does not appear to be affected in practice by variations in luminosity. Moreover, a non-luminous flame of low heating power does not appear to be improved to any appreciable extent by the injection into it of any material, such as a fine spray of oil, which will increase its luminosity.

The local heat transfer from a luminous flame appears in many cases to be more intense than that from flames of low luminosity, but the apparent effect here is only local.

The rate of melting of a layer of batch or scum on the glass surface at a point where the flame impinges often appears much more rapid than the melting of the same material at a point where the flame approaches the surface but does not touch it. This would suggest that heat transfer through combined contact and radiation might be much greater than that by radiation alone.

The heat set free by the combustion of the fuel cannot be dissipated from the flame as quickly as it forms. The non-luminous products of combustion must retain a large part of this heat and be at a high temperature. Transfer of heat from these non-luminous gases which results in a rapid temperature drop to near that of the furnace, if effected entirely through radiation would imply that the radiating efficiency of these gases was high. However, that this is not the case is shown by their very slight effect on a radiation pyrometer, when the pyrometer is sighted through a long furnace filled with hot non-luminous gases.

Radiating Power and Chemical Composition

The radiating power of the flames will vary also with differences in chemical composition, although to an extent much less than that caused by variations in luminosity. Wheeler states that the radiating power of a carbon monoxide flame is two and one-half times that of a

hydrogen flame, although such a difference is seldom apparent in the efficiency of heat transfer from flames composed largely of these gases.

Producer gas very high in hydrogen sometimes gives poor results due to the inevitable high moisture content. Moisture in producer gas does not show in the ordinary analysis yet the content of moisture is one of the most variable of the constituents of producer gas and at times is higher than that of any other constituent except nitrogen. Producer gas is poor enough under average operation but with an extra load of high heat capacity steam, it is not surprising that it gives poor results under some conditions.

Circulation and Heat Transfer

The importance of flame circulation in the furnace as a factor in heat transfer in glass furnaces is usually disregarded, although it is actually the main factor in heat transfer in low temperature furnaces. Circulation can aid heat transfer indirectly by causing the gases to remain in the furnace much longer than they would remain if they followed a definite channel straight through the furnace. Circulation aids heat transfer directly by bringing the hot gases in direct contact with the furnace walls and bath. Much of the heat which is transferred from the flame to the furnace is eventually transferred from the furnace by contact between the outside furnace walls and the gases of the atmosphere; *i.e.*, the radiation loss from the furnace is partly loss through contact.

The momentum of the stream of gas and air flowing into the furnace must induce rapid circulation in the same manner as would a similar stream of water flowing into a vessel full of water. This is especially true in view of the high fluidity of the furnace gases.

This circulation in glass tanks and its high speed is shown even at a distance from the ports by the rapid change which takes place in the stingout from the furnace, when the character of the incoming fuel is changed. In a tank operated on producer gas, the supply of air to the furnace was suddenly decreased. In about a second after cutting the air the stingout from the peep-hole in the rear of the tank showed smoke and in about three seconds, the stingout at the trough in the working end became smoky. The peep-hole was near the corner of the rear wall, about five feet from the flame and at right angles to its direction of flow, that is, in what is usually designated as a dead space, while the trough was about fifteen feet from the nearest flame and separated from it by a bridge-wall.

Circulation Resulting in Direct Contact

Transfer of heat by direct contact takes place in direct proportion to the temperature differential. The rate of transfer by contact is slow

in comparison to the transfer by radiation between efficient radiators at the same temperature, when the temperature of the bodies is high. When, however, the efficiency of the radiator approaches zero, as may be the case with the hot waste gases, the transfer by contact may become more rapid than that by radiation at high temperatures. Consider the apparent difference between the rate of heat transfer by radiation from a hot oxyacetylene flame and the transfer by direct contact with the hot gases from the same flame.

The factor which influences the rate of heat transfer by contact to the greatest extent, is the velocity of flow of the gases. In the flow of fluids in contact with a stationary wall there is always a layer of fluid practically stationary in contact with the wall. The thickness of this layer depends on the character of the fluid and its velocity of flow. Such a layer of gas in a furnace would act as a partial insulator to the furnace walls and bath against heat transfer by contact. If the velocity of flow of the gases in the furnace can be so increased as to cause them to assume a rapid turbulent flow, the insulating layer would be torn off the furnace walls, and a fresh supply of hot gases constantly brought to the surface of the wall.

The momentum of the inflowing stream of fuel is not the only factor present in furnaces which will tend to induce circulation. Combustion of the gases takes place with almost explosive-like rapidity with a consequent very rapid increase in volume and subsequent contraction resulting from the cooling of the flame gases. The cooling of the hot gases in contact with the crown and upper furnace walls should help circulation.

It is suggested that the circulation of the hot gases in glass furnaces may be an important factor in the transfer of heat to the furnace and its contents, especially from the hot gases of low radiating power, and that this factor should be given consideration in changes in the construction and operation made for the purpose of improving heat transfer.

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Columbus, Ohio

ON THE CAUSES OF THE SURFACE DEVITRIFICATION OF GLASSES[1]

By Kozo Tabata

ABSTRACT

The explanation on the causes of the surface devitrification of glasses upon heating, as heretofore considered, is imperfect. The modes of surface devitrification are greatly influenced by the surface conditions of the glasses. The author gives an interpretation on the causes of this phenomenon of surface devitrification, *i.e.*, the surface contraction which is caused by the surface tension at the glass surface acts most seriously toward the surface devitrification.

Introduction

Being supercooled liquids consisting of SiO_2 and B_2O_3 as their acidic- and Na_2O, K_2O, CaO, BaO, PbO etc., as their basic-constituents, together with some other neutral or amphoteric constituents which combine to simple-, double- and complex-compounds, glasses when heated are apt to produce crystals in them. G. Tammann[1] explains this phenomenon of devitrification of glasses from the point of view of "glasses as supercooled liquids." However, observations on this phenomenon made by the author show that in most cases the devitrification occurs on the extreme surface layers of the glasses or at such places where conditions are for the speedy production of crystals. In other words, surface conditions are important in considering the modes of surface devitrification of glasses upon heating.

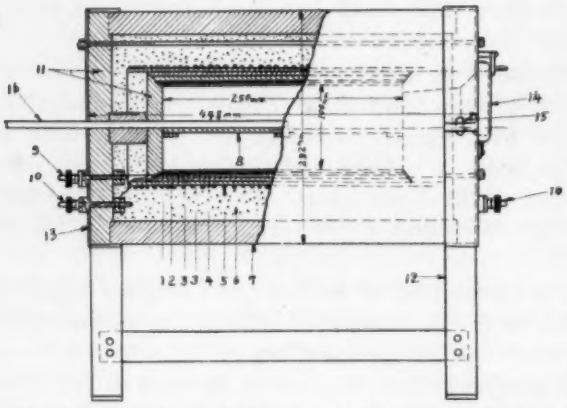

Fig. 1.—Electric muffle furnace. 1, 3, 4, and 7 cylinders made of fire clay; 2 platinum ribbon; 5 nichrome wire; 6 silica powder; 8 sample stand; 9 platinum ribbon terminal; 10 nichrome wire terminal; 11 fireclay cover; 12 iron stand; 13 iron plate; 14 fireclay cover for doorway; 15 bolts; 16 thermocouple.

[1] Reprinted from the Researches of the Electrotechnical Laboratory, No. 165, April, 1926, with the permission of the Director of the Electrotechnical Laboratory, Ministry of Communications, Tokyo, Japan. Received July 19, 1926.

It seems necessary to give some new explanations and interpretations to that phenomenon other than that from G. Tammann,[1] and the present experiments were conducted to reveal the phenomenon by observing the effects of the presence of sharp edges, cicatrices, and bubbles, to the crystal production at the surface layers of the glasses.

Experiments on Devitrification

General Procedure The method of studying the relationship between the ease of crystallization and sharp edges or cicatrices on glass surfaces used in the experiment was as follows. The cleansed samples were put into an electric muffle furnace previously heated to a predetermined temperature, and the temperature was maintained at that point by adjusting resistances in the electric circuit (the deviation of temperature, even in the worst case, having been kept below 5°C), and was measured by a thermocouple made of Pt-PtRh which was accurately adjusted in this laboratory.

After the elapse of a prescribed time, the door of the furnace was opened and the samples were taken out as quickly as possible and allowed to stand in the atmosphere. They were cooled in 2 to 3 minutes to a degree capable of touching by hand. The air-quenched samples were removed from Pt-plates and pasted on a glass plate to be ready for microscopic observations. The microscopic magnifications were from 40 to 1000 and the light used was either reflected or transmitted.

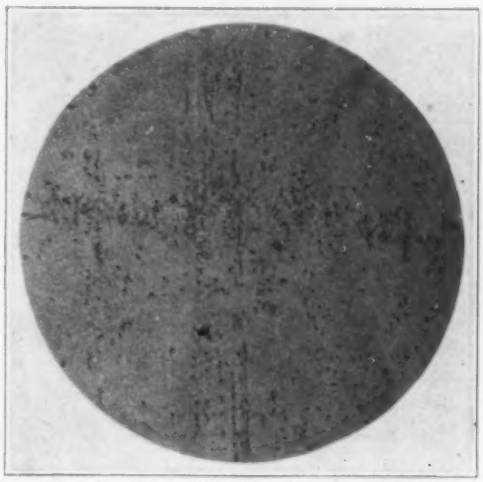

FIG. 2.—Expt. No. 188, Marconi M.T. 4, 600°C–120m.

The photomicrographs were taken on some of the samples by reflected light. The enlargement was 400 in each case.

Samples Samples used in this experiment were taken from depleted radio-transmitting bulbs, Samples Nos. 21 and 22, from newly manufactured radio-transmitting bulbs, Sample No. 27, from glass tubing, Sample No. 25, from old window glass (Japanese made),

[1] G. Tammann, Aggregatzustände, 2te Auflage, 1923; and in *Jour. Soc. Glass Tech.*, 9, 166–85 (1925).

and from melts (from this laboratory), whose chemical composition is as follows:

Expt. No.	SiO_2	Al_2O_3	Fe_2O_3	B_2O_3	CaO	MgO	PbO	MnO	As_2O_3	Na_2O	K_2O	Total
21	72.54	0.82	0.18	14.30	0.34	Tr.	—	—	0.09	4.39	0.30	99.84
22	58.76	0.81	0.13	—	0.49	Tr.	29.31	Tr.	Tr.	7.45	3.30	100.25
25	80.50	2.0	0.25	11.8	0.29	0.06	—	0.01	0.70	4.40	0.20	100.21
27	67.54	5.55	0.05	—	7.43	0.04	—	—	0.07	14.34	4.82	99.84

All the samples were cleansed with diluted acid and alkali, washed with water, and dried in a desiccator. Each kind of sample was stored in a separate glass-stoppered vessel.

To cicatrize the surface of the sample, in most cases, a sharp-edged broken piece of rock crystal was used. Some were cicatrized by a sharp edge of a harder glass and some others by a diamond glass cutter.

For samples of sharp-edged surface of lead silicates, lumps of melted glasses, which were cooled rapidly avoiding devitrification, broken with hammer, and cleansed with de-oiled cotton, were used.

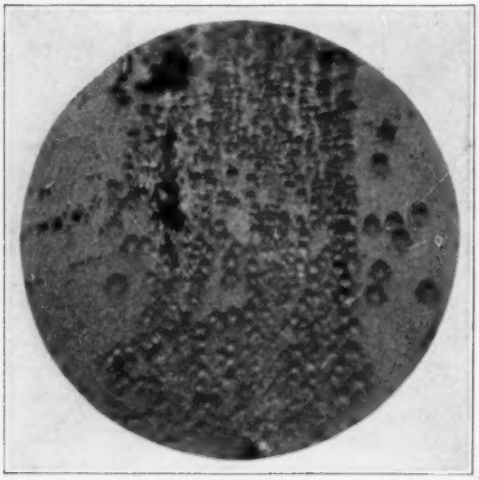

FIG. 3.—Expt. No. 195, Marconi M.T. 4, 625°C–120m.

Samples in which bubbles remained after heat treatment were so ground as to be able to observe bubbles with a microscope without fear of interference of upper and ground surfaces of the samples.

Heating The samples were heated in an electric muffle furnace which was especially constructed for this experiment. Its longitudinal, cross-sectional figure is shown in Fig. 1. Two rheostats were connected in the circuits of a nichrome heater and a platinum heater respectively. Each source of electric power was taken from 100-volt circuits.

To heat the furnace, gradually increasing currents were passed through both heaters. Upon approaching the temperature of the furnace to a predetermined degree, the current of the outer circuit was minimized to a degree just about to compensate the heat loss by conduction and radiation of the furnace, and the current of the inner circuit was abated so that the rise of temperature of the furnace was about 5°C per 10 minutes. After the temperature of the furnace was raised to about 10–15°C above that prescribed, the door of the

furnace was opened and the samples which were put on separate small Pt-plates were charged into the middle part of the furnace nearest to the thermocouple junction. The door was shut and the current was adjusted so as to maintain the temperature of the furnace not to deviate over 2–3°C during this operation.

After an elapse of the prescribed time of heating, the door was again opened and the samples were taken out as quickly as possible and were quenched in the air.

Observations The air-quenched samples were removed from the Pt-plates and were pasted on glass plates to be ready for the microscopic observations.

In most cases, the observations were conducted by transmitted light and in a few cases by reflected light.

FIG. 4.—Expt. No. 194, Marconi M.T. 4, 650°C–60m.

In some cases, the surfaces of the samples were ground just to avert the interference of the unobserved portion.

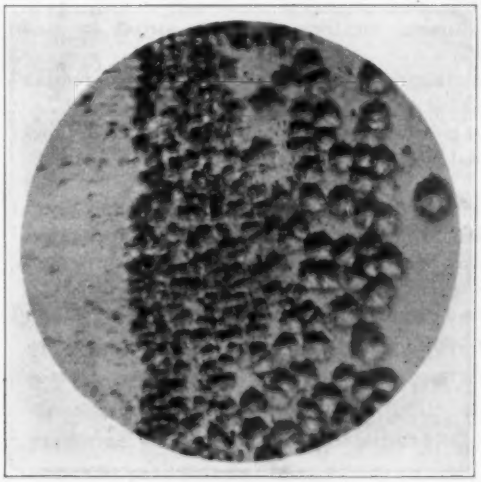

FIG. 5.—Expt. No. 193, Marconi M.T. 4, 675°C–60m.

Photography The microscopically observed samples together with non-heat treated cicatrized samples were photographed at an enlargement of 400 times, and some of them are shown in the accompanying figures.

Tables For each kind of sample glass, the number of experiments, the heating conditions, and the conditions of the samples were tabulated as shown in Tables I, II, III, IV, V, and VI.

TABLE I

FLINT GLASS

Sample No. 22. (Marconi M. T. 4.)

Expt. No.	Temp. °C	Time	Surface conditions
170	650	30m	Cross cicatrice on outer surface by diamond-cutter
171	625	300m	" "
184	750	30m	Cross cicatrice on outer surface by rock-crystal
186	600	30m	" "
187	650	30m	" "
188	600	120m	" "
193	675	60m	" "
194	650	60m	" "
195	625	120m	" "
206	650	60m	Heated 900°C–60m, and air quenched, and cicatrized
207	650	60m	Heated 950°C–60m, and air quenched
212	650	60m	Heated 950°C–60m, and air quenched, and cicatrized
213	650	60m	No cicatrice, heated 950°C–60m, and air quenched

TABLE II

BOROSILICATE GLASSES

Sample No. 25. (Pyrex glass tubing of 2 inches inner diameter.)

Expt. No.	Temp. °C	Time	Surface conditions
172	750	180m	Longitudinal cicatrice on inner surface by diamond-cutter
173	700	180m	" "
174	800	30m	" "
175	800	30m	Longitudinal cicatrice on outer surface by diamond-cutter
176	800	30m	Longitudinal cicatrice on inner surface by rock-crystal
177	800	30m	Lateral cicatrices on inner and outer surfaces by rock-crystal
178	750	60m	Cross cicatrices on inner and outer surfaces by rock-crystal
179	750	30m	" "
180	750	30m	Longitudinal cicatrice on outer surface by rock-crystal
181	850	30m	Cicatrices on inner and outer surfaces by rock-crystal
182	850	30m	Shallow cicatrices on inner and outer surfaces by rock-crystal
183	750	45m	Cross cicatrice on outer surface by rock-crystal and thin cicatrice

TABLE III

BOROSILICATE GLASSES

Sample No. 21. (U. V. 204)

Expt. No.	Temp. °C	Time	Surface conditions
185	750	30m	Cross cicatrice on outer surface by rock-crystal
189	700	30m	" "
192	700	120m	" "

(One with fine line, the other thick line.)

TABLE IV

CA-NA GLASSES

(Old Window Glass, Japanese made)

Expt. No.	Temp. °C	Time	Surface conditions
208	700	60m	Cicatrice by rock-crystal
209	750	60m	" "
210	675	60m	" "

TABLE V

ALKALI-LIME GLASSES

Sample No. 27

Expt. No.	Temp. °C	Time	Surface conditions
196	600	30m	Cicatrice by rock-crystal
197	600	60m	" "
198	650	30m	" "
199	650	60m	" "
200	700	30m	" "
201	700	60m	" "
202	750	30m	" "
203	750	60m	" "
204	800	30m	" "

TABLE VI

ALKALI-LEAD-SILICATES

Expt. No.	Temp. °C	Time	Chemical composition (batch)	Surface conditions
M 6	750	30m	$1.Na_2O, 1.PbO, 5.5SiO_2$	Broken piece
M 18	700	60m	" " "	" "
M 46	820	30m	" " "	" "
M 76	625	60m	" " "	" "
M 90	700	120m	" " "	" "
M 82	675	60m	$1.Na_2O, 1.PbO, 6.SiO_2$	" "

Summary of the Results

From the results of the experiments just described, we see that the surface devitrification of glasses not only depends upon the chemical compositions or constitutions but also suffers a remarkable influence by the presence of sharp edges or cicatrices. It is necessary, when we ascertain the degree of devitrification of any glasses, to define previously the surface conditions in some way, and also to compare the curvatures of the samples before and after the experiments. Otherwise the determined degree of devitrification of the glasses would have no value with respect to the relation between their chemical compositions and the mode of crystal production in them.

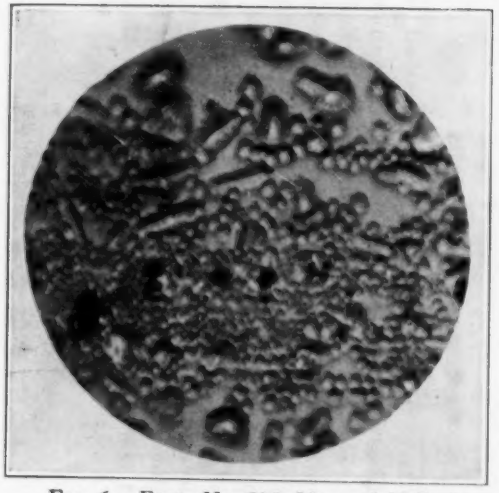

FIG. 6.—Expt. No. 206, Marconi M.T. 4, 650°C–60m.

FIG. 7.—Expt. No. 207, Marconi M.T. 4, 650°C–60m.

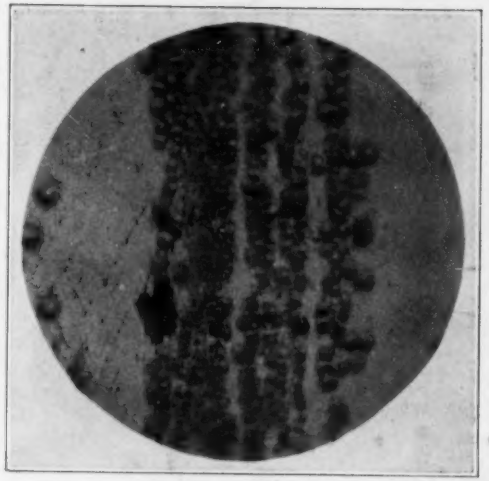

FIG. 8.—Expt. No. 212, Marconi M.T. 4, 650°C–60m.

In Table I and in the accompanying figures, we see that the crystal growths are remarkably increased by the presence of cicatrices. Experiment No. 186 shows that crystals are seen only at the cicatrized parts. Experiment No. 188 shows more crystal growths on the whole surface than Expt. No. 186. The effect of cicatrices is also evident. At higher temperatures, the growths of crystals are larger. On cicatrized parts there are many more crystals in unit area. It is observed that individual crystal growth is hindered by the presence of other crystals of similar sort in its near vicinity.

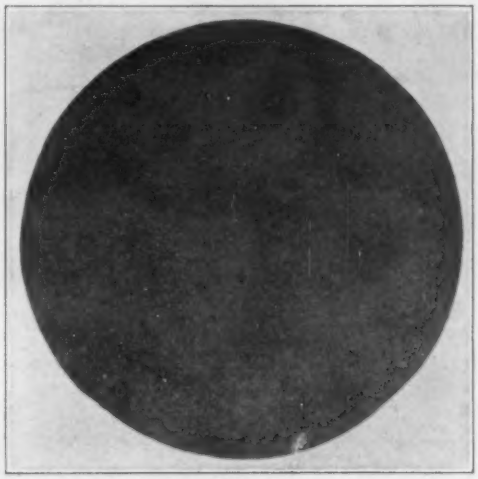

FIG. 9.—Expt. No. 213, Marconi M.T. 4, 650°C–60m.

In Expt. No. 207, we see that the presence of some crystals (not so many as will hinder other crystal production) will be somewhat convenient to the crystal production on reheating.

FIG. 10.—Expt. No. 173, Pyrex glass, 700°C–180m.

In Expt. No. 206, we see also that the effect of the presence of cicatrices is so great that the effect of the previous presence of some crystals may be thought to be negligible (compared with that of cicatrices).

Experiment No. 212 also shows the great effect of the presence of cicatrices. Experiment No. 213 shows that on a perfectly smooth surface there is not a single crystal produced by the same heat treatment. This is a proof of the closeness of the relation between the surface conditions and the mode of crystal growth on glass surfaces.

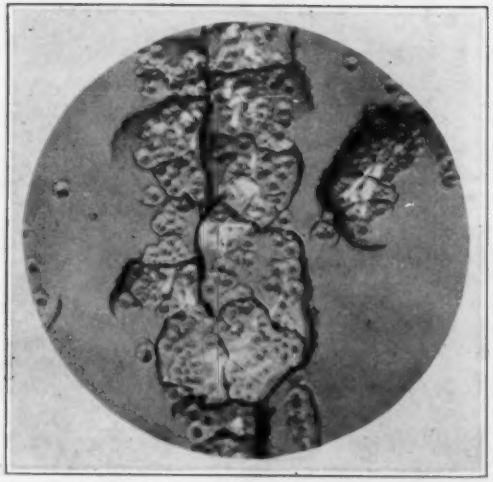

FIG. 11.—Expt. No. 174, Pyrex glass, 800°C–30m.

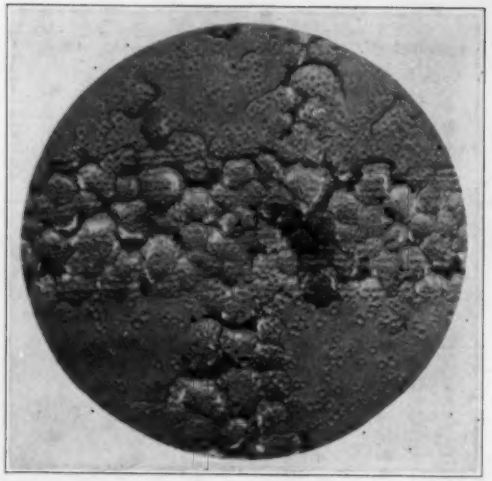

FIG. 12.—Expt. No. 178, Pyrex glass, 750°C–60m.

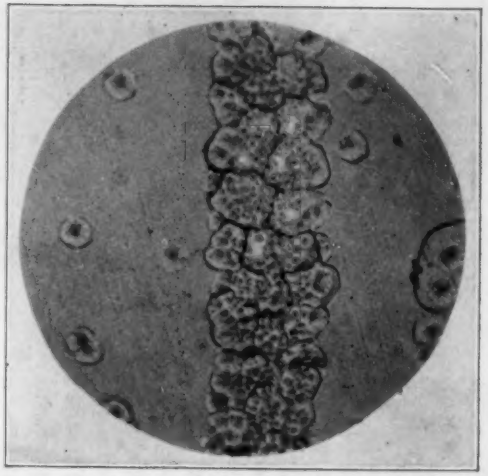

FIG. 13.—Expt.. No. 181, Pyrex glass, 850°C–30m.

In the case of Sample No. 25, the first appearance of crystals was at a higher temperature. Its softening temperature (1 cubic cm begins to change its form by its own weight) is said to be about 750°C. In all the experiments, the growths of crystals were vigorous at the cicatrized parts and at the edges of the sample pieces. The crystals grew more rapidly. After cooling, the boundaries of the crystals were plainly cracked. The formation of cracks around a single crystal or group of crystals may be caused by the rapid cooling, together with the great rate of the crystal growth. The greater rate of linear growths of crystals may be attributed to the greater rate of motion of the molecules or of more energy content in the molecules on the surface film of the crystals. Considering at the same time, the greater viscosity of the mass and the forms of crystals, in this case, we shall see that the compositions of crystals are different from those produced in flint glasses. The SiO_2 content of this glass is greatest among glasses technically made. The author doubts the statement that "some types of borosilicate glasses may devitrify with separation of spherulites of tridymite, SiO_2" by N. L. Bowen.[1]

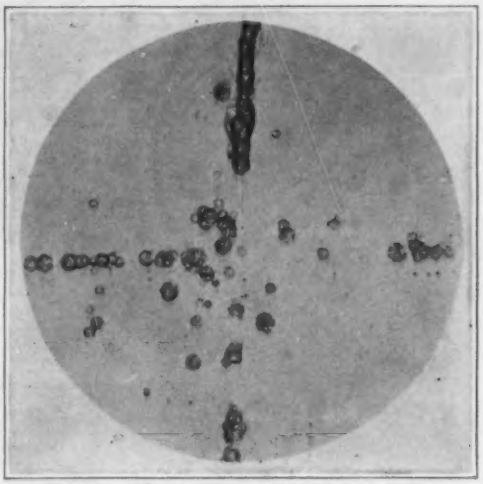

FIG. 14.—Expt. No. 185, U.V. 204, 750°C–30m.

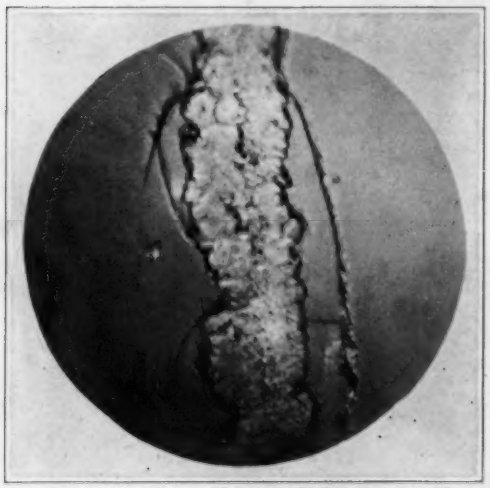

FIG. 15.—Expt. No .192, U.V. 204, 700°C–120m.

The modes of devitrification differ somewhat on inner and outer surfaces. This may be attributed to the difference of curvature of these surfaces.

[1] *Jour. Amer. Ceram. Soc.*, **2**, 273 (1919).

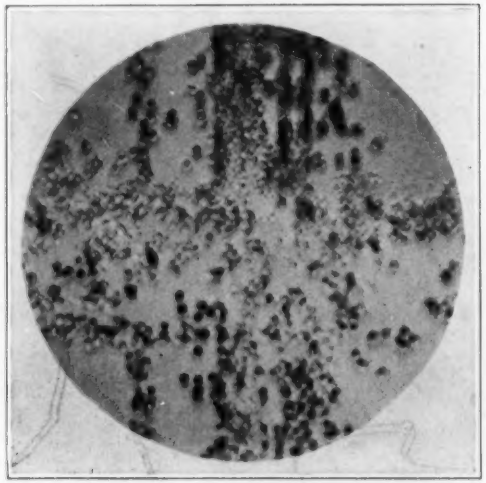

FIG. 16.—Expt. No. 208, Window glass, 700°C–60^{m}.

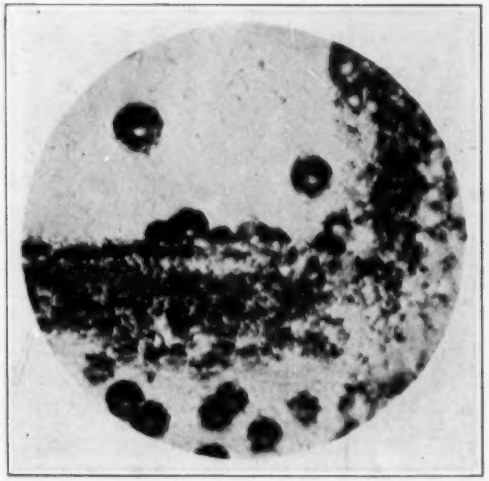

FIG. 17.—Expt. No. 209, Window glass, 750°C–60^{m}.

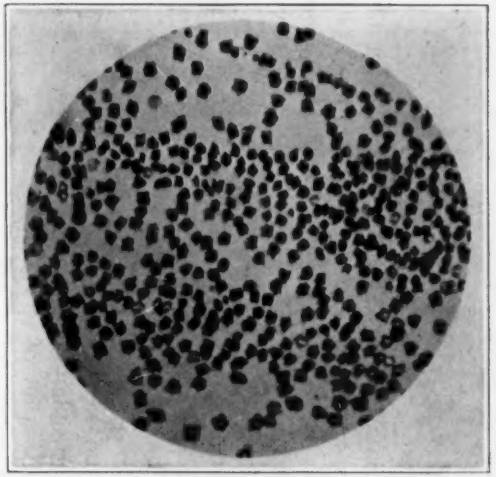

FIG. 18.—Expt. No. 18(M), 1.Na_2O, 1.PbO, 5.5.SiO_2, Sharp edge, 700°C–60^{m}.

In the photographs, we see again the remarkable influence of the presence of cicatrices upon the devitrification of glasses.

In the results of the experiments on Sample No. 21, we see the same influences of the presence of cicatrices on the mode of devitrification. The crystals produced in them are about the same as those in Sample No. 25. The viscosity is smaller at 700°C and the sharp edges are rounded in some degree at that temperature. Another experiment at lower temperatures shows that, due to the very slow crystal growth, it is difficult to find any crystals even after hours of heating at 600–625°C.

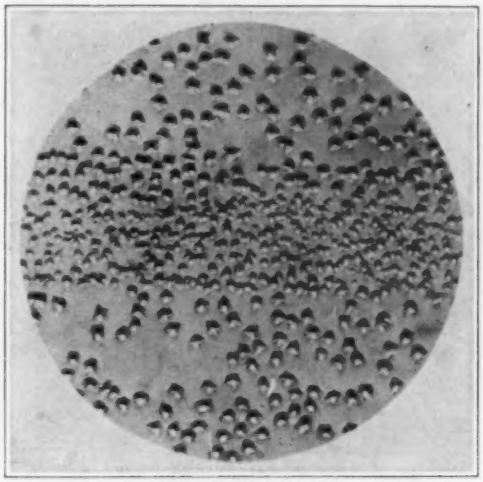

FIG. 19.—Expt. No. 18(M), 1.Na_2O, 1.PbO, 5.5.SiO_2, Cicatrix, 700°C–60m.

In Expt. No. 192, we see the differences in the forms of cicatrices will affect the difference on the mode of crystal growths. On single or shallow cicatrices, single crystals grow separately and on a number of cicatrices nearby assembled or on a broken surface where many sharp edges are present side by side, the crystals agglomerate, losing their own perfect form.

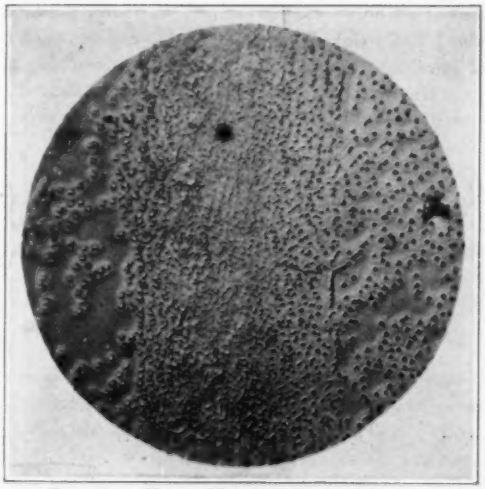

FIG. 20.—Expt. No. 29(M), 1.PbO, 2.SiO_2, 700°C–60m.

In the results on window glass (whose chemical composition was not determined) we see also a marked influence of cicatrices. In Fig. 17 (Expt. No. 209), we see some large crystals which are produced on other parts of the cicatrized portion. The difference in the number of crystals produced on those parts is indeed remarkable. The form of crystals produced is spherulitic.

The results on Sample No. 27 show that this glass does not devitrify at all under the heating conditions described.

In the results of the experiments on the lead silicates and alkali-lead-silicates melted in this laboratory, the influence of the presence of cicatrices, etc., are observed in the same way.

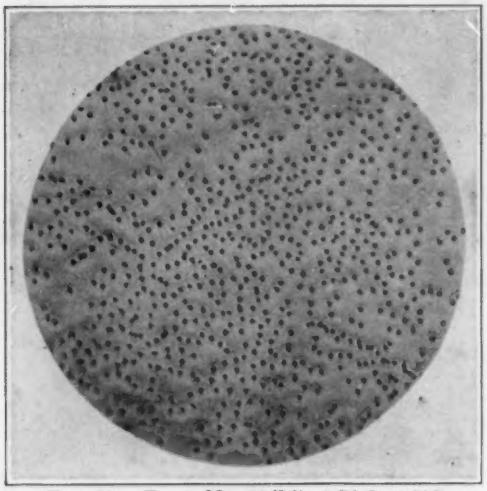

FIG. 21.—Expt. No. 29(M), 1.PbO, 2.SiO_2, No cicatrix, 700°C–60m.

Supplementary Experiments

Figures 22 to 29 (229*a* to 237*b*) show the results of experiments which were conducted for the interpretation of the phenomena of the surface devitrification of glasses. The samples were taken from a depleted Marconi M. T. 4 bulb.

The conditions of the experiments and the results were as follows: (all the samples were air quenched after previous heating; same number of experiments means that the heat treatment was conducted at the same time).

Expt. no.	Temp.-time	Previous heating	Remarks
229 *a*	725°C–60m	1000°C–60m	Without detaching from Pt-plate after previous heating, the air-quenched sample was cicatrized. The surface contraction was not conspicuous as a whole owing to the adhesive force acting between Pt-plate and the glass. The wrinkles covered all the surface; each seemed to have got a form of minimum surface area during air quenching; the changes during the after-heat treatment were very small. At the cicatrized part, the wrinkles being removed by the cicatrization, the crystals were produced as usual.
299 *b*	725°C–60m	1000°C–60m	The same as above except non-cicatrizing. The wrinkles were somewhat larger. No crystals produced.
231 *a*	725°C–60m	1000°C–60m	Detached from Pt-plate after previous heating, cicatrized. The surface contraction was remarkable as a whole. The sample became round. The crystals were produced all over the surface, especially more crystals at the cicatrized portion.
231 *b*	725°C–60m	1000°C–60m	Just the same as 231 *a*, except non-cicatrizing.
234 *a*	725°C–60m	950°C–60m	Without detaching from Pt-plate after air quenching, cicatrized. The crystals appeared only at the cicatrized portion.
234 *b*	725°C–60m	950°C–60m	The same as above, no cicatrix. No crystals as a whole.
235 *a*	725°C–60m	950°C–60m	Detached from Pt-plate after air quenching, cicatrized. Numbers of crystals on the whole surface seem less than 231*a* many at cicatrized portion.
235 *b*	725°C–60m	950°C–60m	The same as above, no cicatrix.
237 *a*	725°C–60m	910°C–60m	Detached from Pt-plate after air quenching, cicatrized. Whole surface was covered with crystals produced

at 910°C heating. New crystals along cicatrized parts only.

237 *b*	725°C–60^{m}	910°C–60^{m}	The same as above, no new crystals.

Interpretation of the Phenomena

According to the electronic consideration, J. J. Thomson describes in his book, "The Electron in Chemistry," pp. 131–33, 1923, that the surface tension of solids and liquids is established by the difference between the quantities of energy possessed by the atoms or molecules which are present in a unit area of the outermost surface and of inner layer, and that atoms or molecules in the surface layer possess more potential energy than that of similar ones in the interior. The chemical activity, etc., of the former atoms or molecules is greater than the latter.

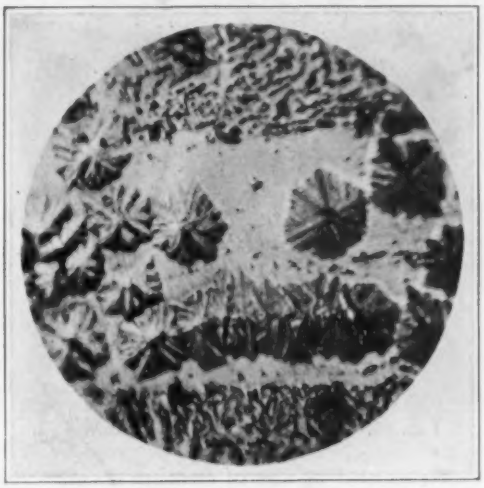

FIG. 22.—Expt. No. 299*a*, Marconi M.T. 4.

Referring to the above exposition, the author gives the following interpretations of the phenomenon of surface devitrification of glasses; and also of the remarkable influence caused by the presence of cicatrices, sharp edges, bubbles, etc.

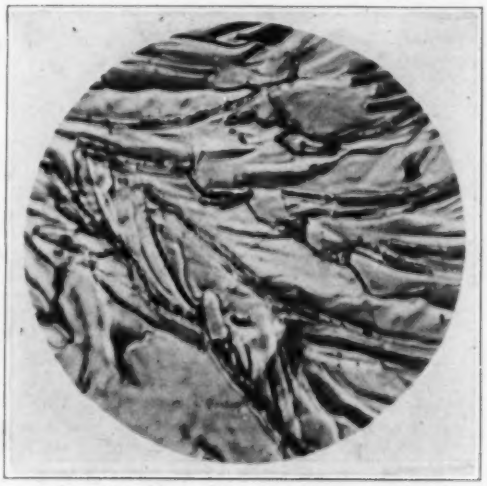

FIG. 23.—Expt. No. 229*b*, Marconi M.T. 4.

1. When glasses are heated to a temperature where the viscosity becomes small enough to affect the motions of atoms or molecules which are in some range of speed so as to have more chance of combination between them, the atoms or molecules at the surface layer will have the best chance of combination, owing to their greater potential energy, and by the contracting force acting toward forming the least surface area of the mass.

In other words, when glasses—supercooled liquids having very large viscosities at lower temperatures so that the atoms or molecules in them are hindered at some rates of speed for speedy combination—are heated to a temperature where the viscosities of mass become small and when the surface tension, as caused by the difference of energies of atoms or molecules per unit area of the outermost layer and of the inner layer, results in a marked contraction of the surface, the atoms or molecules at the surface layer having more energy than those of the inner layer, will come nearer to each other and will have more opportunities and power of combination.

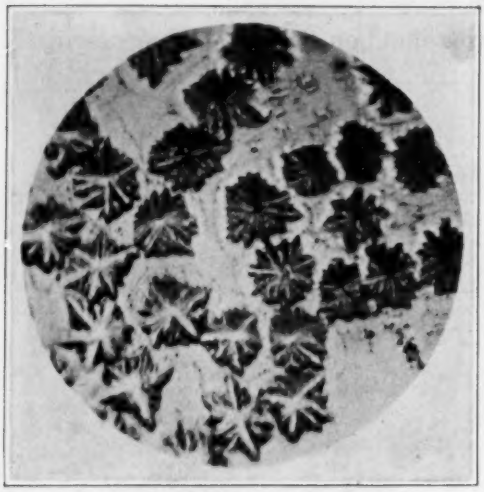

FIG. 24.—Expt. No. 231*a*, Marconi M.T. 4.

The phenomena were demonstrated by the author as follows:

Sample 22 was used in this experiment; the crystal to be produced in it was SiO_2 and the temperature of remelt was about 950°C where the viscosity of the mass had a little value so that the mass had somewhat flattened spheric form after heating. Upon heating at about 1000°C the mass flowed and took a flat form. These properties were very advantageous for the demonstration of the phenomena. It was for this reason that Sample No. 22 was used.

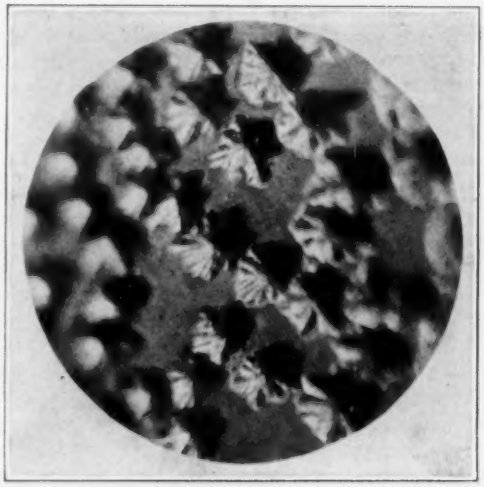

FIG. 25.—Expt. No. 231*b*, Marconi M.T. 4.

Samples put on separate Pt-plates were heated at 1000°C for 60 minutes, were air-quenched and heated again at 725°C for 60 minutes. They adhered to the Pt-plate at the bottom surface so that the volume contraction was hindered during

the second heating. They maintained a flat surface. It was observed that the crystal formation on the surface layers was small. At points where some disturbances might have occurred during the second heat treatment by some causes, there some crystals were found.

Other samples, heated at 1000°C for 60 minutes and air-quenched, were unfastened and heated again at 725°C for 60 minutes. The whole mass contracted and took somewhat spheric form after the treatment. It was found, in this case, that the crystals grew on all the surface layers.

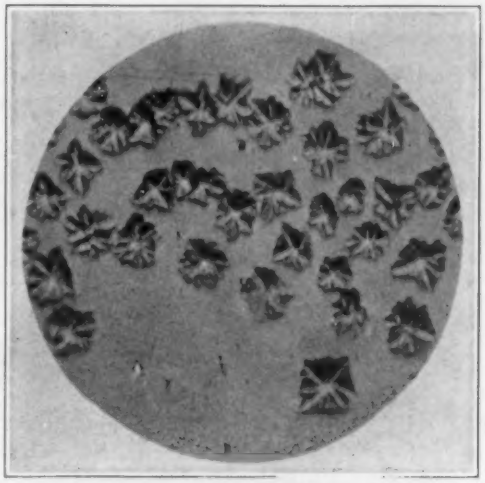

FIG. 26.—Expt. No. 234*a*, Marconi M.T. 4.

The difference in the modes of crystal growths in both cases was indeed conspicuous.

Thus, the author considers that the cause of the surface devitrification of glasses is quite clear and also that the reason of that phenomenon is evidenced by the above interpretations.

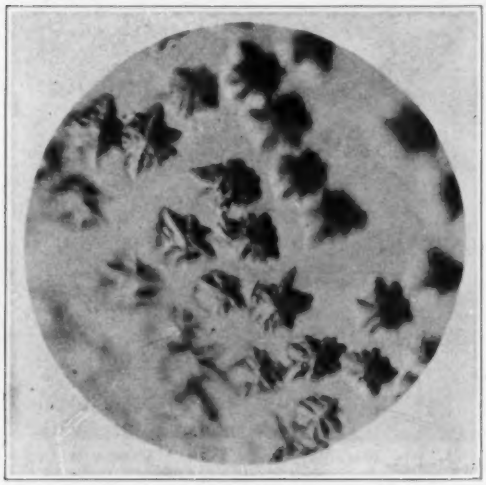

FIG. 27.—Expt. No. 234*b*, Marconi M.T. 4.

2. For the cause of the influence of the cicatrices, sharp edges, etc., the author gives the following interpretations. The quantity of energy sustained in atoms or molecules and also in unit area of the surface layer differs according to the curvature of the surface. The sharper the curvature the more would the energy be sustained in unit area.

Thus in the cicatrized portion or sharp-edged portion on the glass surface, there will occur easier crystallization and there will be more crystal nuclei formed.

The accompanying photoplates in Part I are the proof of the interpretations. It is seen that at the sharp-edged portions (or cicatrized parts) the crystals appear under microscopic observation, at lower temperatures than other portions non-sharp-edged (or non-cicatrized) and also that the number of crystals produced is much greater, so that we may think of the greater rate of production of crystal nuclei on these parts than other parts.

FIG. 28.—Expt. No. 235*a*, Marconi M.T. 4.

3. The effect of bubbles with reduced pressure in glasses was explained the same as 1, p. 19, except that the form of bubbles was about spheric in most cases so that surface contraction of the surrounding film was not so large as in other cases.

The effect of bubbles was not so remarkable as the foregoing cases. For the demonstration of the influence of their presence, the author used melts 1PbO, $3SiO_2$ and 1PbO, 2.5 SiO_2 from which crystals of SiO_2 have appeared. Samples which contained bubbles (which did not aggregate) were heated at 850°C for 60 minutes and air-quenched, heated again at 700°C for 120 minutes. Microscopical observations showed the crystal growths of a similar kind those of the surface layer which occurred somewhere on the surrounding surfaces. However, where many bubbles appeared very near to each other or where bubbles were produced during heat treatments, the author found no crystals growing. These experiments will also be one of the proofs of the action of surface contraction on the surface devitrification of glass.

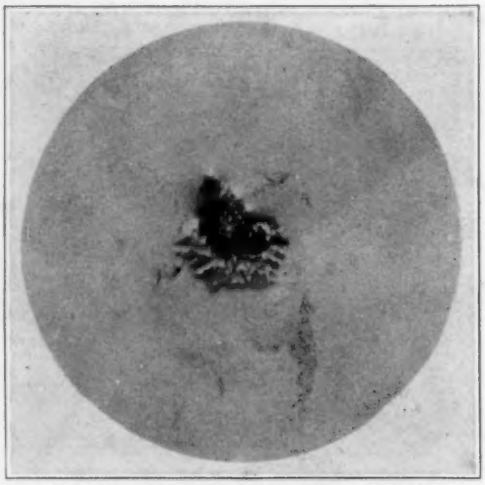

FIG.29.—Expt. No. 235*b*, Marconi M.T. 4.

The author concludes that the mode of action of surface tension on glass surfaces is the most important factor in deciding the degree of devitrification on a glass surface.

A MICROPHOTOGRAPHIC STUDY OF FREE QUARTZ IN FELDSPAR[1]

By A. Malinovszky

ABSTRACT

The study presented in this article is of the quantity and variations of the free quartz in feldspar estimated by means of microphotographs and calculations based upon them.

The microphotographs will illustrate what great quantities of free quartz are generally present and not only variations in quantity but also in form of the quartz will at once be apparent. Such a wide range both in quantity and form cannot help but radically affect the coefficient of expansion of a feldspar and it will naturally be reflected in the variable results obtained through its use.

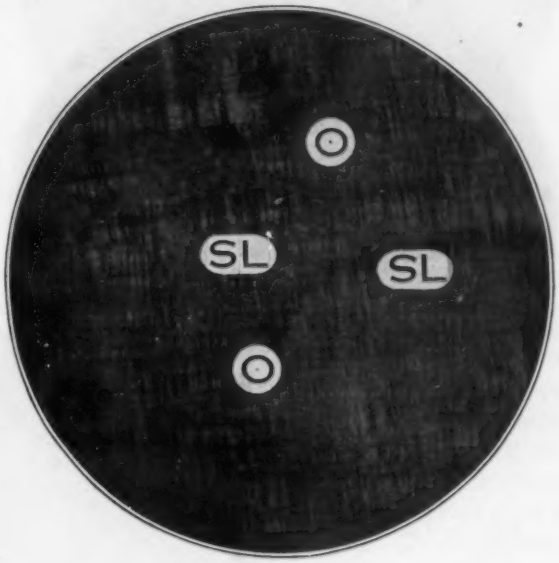

Fig. 1.—Magnified 20.

In the porcelain enamel industry it is well known that any considerable variation in the feldspar used is bound to cause either chipping or crazing.

In the pottery industry this variation in feldspar will cause a failure of the clay body and the glaze to fit and the result will be dunting of the body and shivering of the glaze.

By a variable feldspar is meant one with a changing coefficient of expansion which may be caused by the quantity and character of its contained free quartz.

In all cases these microphotographs were prepared by crossed nicols. The enlargements are about 20. Figures 9 and 10 are enlarged 40 times because this rock is very fine grained. It will be noticed that the undissolved free quartz fragments in all prints are very apparent as light spots in dark fields.

[1] Received April 6, 1926.

The mark *O* on the prints indicated orthoclase and microcline. *SL* represents soda-lime feldspar oligoclase.

Figure 1 shows a light pinkish which is almost white microcline feldspar with about 8% oligoclase intergrown with it. Quartz and kaolin are present.

Figure 2 shows the fused feldspar of the same sample as Fig. 1 containing many round bubbles. Here the undissolved quartz fragments show about 8% and are of an average size of .002 to .0025 inch. There is also a trace of a light brownish semifused substance believed to be decomposed chloride.

FIG. 2.—Fused (magnified 20) 8% of free quartz.

Figure 3. This sample was taken from the White Rose Mine at San Diego, Calif. It is a brownish-pink orthoclase feldspar with about 5% intergrown oligoclase, quartz, and kaolin present.

Figure 4 represents the fused feldspar of Figure 3, showing a clear glass, with very few bubbles present. There is only about 2% undissolved quartz present. The quartz fragments are rounded indicating partial solution.

Figure 5 represents nearly white microcline feldspar. Intergrown through it are stringers of oligoclase amounting to about 8%. A slight variation is present in the form of a trace of kaolin and quartz.

Figure 6 is a section of the fused feldspar of the same sample as Fig. 5. The sample is almost a colorless glass rather thickly set with round bubbles. It contains approximately 15% of undissolved quartz in small fragments averaging about .001 of an inch in size.

Figure 7 is a white microcline feldspar with an intergrowth of about 8% oligoclase feldspar. The sample shows quartz, sericite, and kaolin present.

Figure 8 represents the fused sample of the same feldspar as Fig. 7, containing about 12% undissolved quartz fragments that vary widely

in regard to size. The fragments would perhaps average about .001 of an inch in size. A brownish substance is also clearly present which is probably decomposed chlorate and mica.

Figure 9 represents the raw sample of a Cornish stone, found in California near Los Angeles. It is a very fine grained granular rock, composed of orthoclase feldspar, quartz, and albite feldspar. The grains are so fine that it is very difficult to calculate proportions under the microscope and therefore a large allowance must be made for error. The proportions are about 20 orthoclase, 35 albite, and about 45 quartz.

FIG. 3.—Magnified 20.

FIG. 4.—Fused, magnified 20. Notice the few free quartz grains, 2% of free quartz.

Most of the quartz is fine granular but some is arranged in pockets or stringers of somewhat larger crystals and on these determination was made. Albite occurs in small flat crystals and also as irregular grains. Orthoclase occurs only in small grains; determinations were made from birefringence only.

The flat grains without relief are quartz. The longish rough crystals are albite and the regular background mostly orthoclase.

FIG. 5.—Magnified 20.

Figure 10 represents the fused sample of Fig. 9, which shows in section a clear glass containing about 15% of unfused residue of silica. This residue does not appear as grains but as thin irregular forms. These may be the quartz that was intimately intergrown with feldspar after the latter has been melted out and has partially dissolved the quartz. The sample contains a few large bubbles. The residual undissolved silica is white or gray, the glassy part of the sample in the print is black.

TABLE I

ANALYSES OF THE FIVE SAMPLES

	1	3	5	7	9
SiO_2	66.71	64.82	70.02	72.00	78.30
Al_2O_3	19.91	19.48	16.71	14.50	13.70
Fe_2O_3	.19	.25	.11	.30	.03
CaO	.85	.94	.60	.30	.30
MgO	.23	.36	.03	.54	.68
K_2O	9.12	11.20	10.32	7.08	2.78
Na_2O	2.89	2.88	2.27	5.22	4.00
Ignition Loss	.10	.07	———	———	———

CALCULATED PROPORTIONS

	1	3	5	7	9
Orthoclase	53.92	66.25	61.04	41.88	16.44
Albite	24.42	24.34	19.18	44.13	33.81
Anorthite	4.22	4.63	2.98	1.49	1.49
Kaolin	9.41	2.28	1.24	.....	8.98
Free quartz	8.75	2.14	15.46	13.92	38.63
Free quartz by micros	8.00	2.00	15.00	12.00	45.00
Coefficient	2.65	2.79	2.53	2.45	1.87

All samples were carefully fused in order to avoid dissolving action

of the free quartz. Sample, Fig. 10, was fused in a commercial kiln.

Calculations of free quartz in the above feldspar samples by chemical analyses checked very close to the results obtained by petrographic examination. This proves that a careful chemical analysis with accurate calculations will give a fairly true estimate of the quantity of free quartz present in a feldspar.

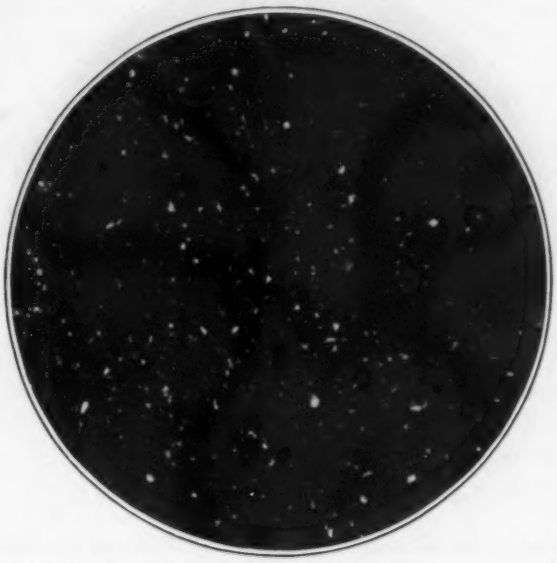

FIG. 6.—Magnified 20. Fused sample contains 20% of free quartz.

Feldspar, however, should be analyzed after it has been ground; this analysis after grinding will invariably show a higher silica content than an analysis taken before grinding. This is caused by the amount of silica picked up by the feldspar during the grinding operation from the mill lining and mill balls.

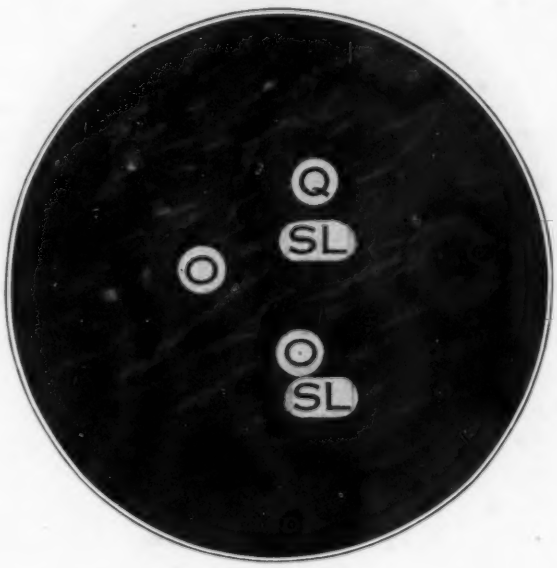

FIG. 7.—Magnified 20.

The four samples of feldspar given show a great difference in their coefficient of expansion. By drawing a graphic chart of the four different coefficients of expansion, it will be more apparent how important a factor in obtaining

FIG. 8.—Fused sample. Magnified 20. Contains 12% free quartz.

In the above five samples the CaO was calculated as anorthite instead of oligoclase. This was done to simplify the method for those who may use the following calculation methods.

Molecular Weights	
Orthoclase feldspar	556
Albite feldspar	524
Anorthite feldspar	278
Kaolin	258

Sample No. 1

$$\frac{556 \times 9.12}{94} = 53.92 \text{ orthoclase}$$

Contain

$$\frac{53.92 \times 360}{556} = 34.91 \ SiO_2$$

constant results it is to have a large quantity of feldspar always on hand.

The SiO_2 content of a feldspar should always be checked by a hydrofluoric acid volatilization. This is one of the quickest methods and quite accurate if carefully done.

The calculations of the coefficient of the feldspar by Schott's method is the best adapted to use in calculating enamels, terra cotta, white ware, porcelain, etc.

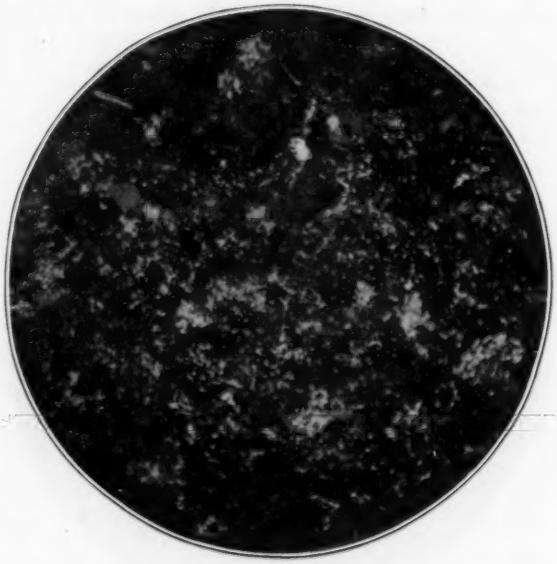

FIG. 9.—Magnified 40 times.

$$\frac{53.92\times102}{556} = 9.89\ Al_2O_3$$

$$9.12\ K_2O$$

$$53.92$$

$$\frac{524\times2.89}{62} = 24.42 \text{ albite}$$

Contain

$$\frac{24.42\times360}{524} = 16.78\ SiO_2$$

$$\frac{24.42\times102}{524} = 4.75\ Al_2O_3$$

$$2.89\ Na_2O$$

$$24.42$$

$$\frac{278\times.85}{56} = 4.22 \text{ anorthite}$$

Contain

$$\frac{4.22\times120}{278} = 1.82\ SiO_2$$

$$\frac{4.22\times102}{278} = 1.55\ Al_2O_3$$

$$.85\ CaO$$

$$4.22$$

FIG. 10.—Magnified 40 times. Fused contains 40% free quartz.

Total SiO_2 combined: $34.91+16.78+1.82+4.45=57.96$.

Total Al_2O_3 combined in feldspar: $9.89+4.75+1.55=16.19$.

Total Al_2O_3 found by analyses: $19.91-16.19=3.72$ which is calculated for kaolin.

$$\frac{258\times3.72}{102} = 9.41 \text{ kaolin}$$

Contain

$$\frac{9.41\times120}{258} = 4.45\ SiO_2$$

Total SiO_2 found by analyses: $66.71-57.96=8.75$% free quartz.

The other samples have been calculated by the same method.

WASHINGTON IRON WORKS
LOS ANGELES, CALIF.

THE THERMAL CONDUCTIVITY OF SOME REFRACTORIES[1]

By F. H. Norton[2]

ABSTRACT

The problem of measuring the thermal conductivity of materials up to high temperatures has been studied, especially in regard to the sources of error. This investigation has shown that many of the previous determinations of thermal conductivity may have had little precision due to a lack of appreciation of the errors involved. The values of thermal conductivity for a number of refractories are given, as obtained by a new type of apparatus designed to eliminate to a considerable extent the errors of measurement. However, it is believed that these values may have an error as high as ±25% for the better heat conductors; so there is still much work to be done in developing a method for measuring thermal conductivity with the precision usual in other physical measurements.

I. Introduction

It is usual to determine the thermal conductivity of a material by setting up a steady lineal flow of heat and measuring the quantity of heat flow and the temperature gradient. From these figures the conductivity is computed from the following equation derived from Fourier's equation of heat flow.

$$\text{Conductivity} = \frac{\text{Heat flow}}{\text{Temp. gradient}}$$

In applying this equation the assumption must be made that the conductivity of the material is independent of the quantity of heat flow. In the same way Ohm's law is only valid if the resistance of the material is independent of the current density. As yet, we have no direct evidence that the conductivity depends on the quantity of heat flow and it would seem that this assumption is justified, at least, until we are able to obtain a much greater precision in our conductivity tests.

The first practical problem that comes up in measuring conductivity is to establish a steady lineal flow of heat. This might be thought a simple condition to fulfil, but actually it is the most difficult problem encountered in conductivity measurements.

A number of investigators have measured the conductivity of a material by forming it into a spherical shell and allowing the heat to pass from the interior to the outside. This arrangement provides the same flow of heat through every part of the material, entirely eliminating lateral flow. However, the flow of heat is radial so it would be necessary to consider the shell infinitely thin, or integrate a shell of finite thickness to determine the correct area of surface. This method

[1] Received September 16, 1926.

[2] Babcock and Wilcox Fellow, Division of Industrial Coöperation and Research, Mass. Institute of Technology.

also has the disadvantage that it cannot be readily used at high temperatures.

Another method that has been used very successfully for a number of years to measure the conductivity of pipe covers, employs a specimen in the form of a long cylinder with a heater inside. A correction is made for the end losses. In this case, as with the sphere, the heat flow is radial which introduces complications into the measurement. Recently, some tests have been made at relatively high temperatures with this method by Clemont and Egy.

The most used and perhaps the most attractive method of measuring conductivity is to employ the specimen in the form of a flat plate through which the heat is made to flow lineally. This method has been used at high temperatures by Dudley, Green, Wologdine, and others, but in all cases the difficulty has been to prevent heat flowing laterally from the edges of the plate.

The quantity of heat may be measured by using an electric heater to which a known amount of energy is supplied; however, the temperature is limited by this means to about 1000°C on the hot face, unless platinum or molybdenum coils are used. The quantity of heat can also be measured by absorbing it on the cool face by a calorimeter.

The temperature gradient through the material can be measured most readily by thermal junctions embedded at various points. In some of the earlier tests, these junctions were simply laid against the surfaces, but it was later found that the temperature readings were greatly in error and in more recent tests the junctions have been carefully embedded in the material and the surface temperature extrapolated. In some of the investigations the temperature gradient has been measured by a couple entering the material parallel to the heat flow in such a way that it could be moved to any distance in the material. This method is very convenient as it gives a continuous temperature gradient but as will be shown later it will lead to erroneous readings near the cool surface due to conduction along the wires of the couple.

An entirely different method of measuring conductivity was first tried by Ångström[1] in which it was unnecessary to measure the quantity of heat flow. The method consisted in applying to the hot surface of the material, a source of heat which varied in temperature harmonically. The temperature was then measured at several points in the material and from the time lag and decrease in amplitude of the temperature, the values of diffusivity could be calculated. As the diffusivity is equal to the conductivity divided by the density and the specific heat, the

[1] *Ann. Chim. Phys.*, 3 etom, IXVII, p. 379.

value of the conductivity can readily be obtained. This method has been refined by Tadokoro[2] but has the same inherent difficulties of obtaining a lineal flow of heat as the preceding method and is more complicated to use.

II. Preliminary Studies

After considering the various methods that had been used to measure thermal conductivity at high temperatures, it was decided to construct a large furnace with test walls built in the doorways. Calorimeters were mounted on the outside of these walls and large guard rims surrounded them. The furnace is shown in Fig. 1 and consisted of an approximately cubical chamber three feet on a side. Gas and air were introduced under the crown through a nozzle supplied by a premix blower. The bottom of the chamber was perforated and connected by flues to a stack of such height as to obtain approximately atmospheric pressure in the furnace. The test walls were 70 cm. square set on opposite sides of the furnace, and sight tubes were provided for taking optical readings at the center of each wall.

FIG. 1.—General view of first furnace.

The test wall was carefully laid up in each doorway of 6.35, 11.4, or 22.8 cm. thickness and the inner and outer surfaces were evenly coated with a layer of cement. The cool face of the wall was covered with several thicknesses of asbestos paper and the calorimeter was held tightly against it by means of a spring. The calorimeter (12 cm. in diameter) was then surrounded by the inner guard ring (25 cm. in diameter) and outer guard ring (68 cm. square), each

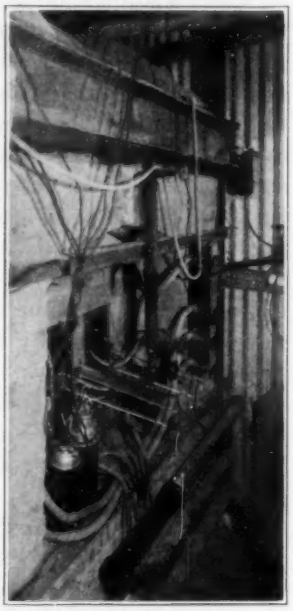

FIG. 2.—First furnace, calorimeters and apparatus showing sliding thermocouple.

[2] "On the Determination of the Thermal Conductivity, Specific Heat, Density, and Thermal Expansion of Different Rocks and Refractory Materials," First Report on the Lab. of the Imperial Steel Works.

one of which was held snugly against the wall. The calorimeter and inner guard ring were covered on the outside with 2.5 cm. of hair felt (Fig. 2).

Two methods of measuring the temperature gradient were tried out as shown in Fig. 3. In one case the method of Dudley was used. A small hole about 6 millimeters in diameter was drilled into the center of the wall at right angles to the face, penetrating within a few millimeters of the hot surface. Into this hole was cemented a closed end porcelain tube inside of which a platinum thermocouple could be slipped to any depth through a hole in the center of the calorimeter. In addition to this couple, six fixed couples were cemented in grooves cut in the upper and lower surfaces of the central brick in the wall. The leads from these couples ran at right angles to the direction of heat flow as far as the outer guard ring where they were brought to the cool surface of the wall. The four couples near the hot face were platinum couples while the others were of base metals. Besides these couples there were placed, in various tests, other couples at exactly the same distance from the cold face of the wall but at various distances from the center. The couples were brought out to cold junctions in thermos bottles filled with ice water and led to switches for connection to a potentiometer.

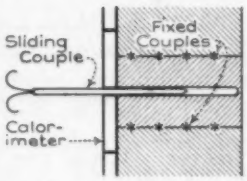

FIG. 3.—Location of couples in wall.

The temperature in the furnace was brought up to the desired value and usually held constant twelve to twenty-four hours to insure a complete heat balance. Then two one-half hour runs were made a few hours apart. The average temperatures of the calorimeter and the two guard rings were maintained within 0.2°C of each other. The temperature at one point inside the furnace did not vary more than 5 to 10°C during the run and the temperature of the inside of the furnace varied not more than 30°C from place to place. It was possible to obtain easily a temperature in the furnace of 1700°C.

It will be noted that the guarding of the calorimeter is unusually complete, in fact, more complete than in any previous tests that have come to my knowledge. The greatest care was taken to calibrate the thermocouples before and after each run against a standard couple and the optical pyrometer was checked up frequently with a standard instrument.

The Measurement of the Temperature Gradient

Let us consider a typical run on an 11.4 cm. wall where both the sliding couple and the fixed couples were used. As shown in Fig. 4 the temperature gradient as determined from the

fixed couple is approximately a straight line. On the other hand the curve obtained from the sliding couple shows a marked falling off in temperature at the cool surface which is not indicated by the fixed couples. This type of curve is identical with those obtained by Dudley and later by Hartmann using the same type of couple. It seems reasonable to believe that the temperature gradient determined by the sliding couple is in error at the lower temperatures due to the conduction of heat along the wires of the thermocouple to the relatively cool calorimeter. While the straight line temperature gradient shown by the fixed couples is not correct, as will be shown later, the error is due to a different cause and does not discredit the readings taken by means of the fixed thermocouples. The curve shown in Fig. 4 is not a single test but was obtained in substantially the same form on large numbers of other materials. It may be stated in general that to measure accurately the temperature gradient in any material the thermocouples should always pass across rather than parallel with the direction of the heat flow.

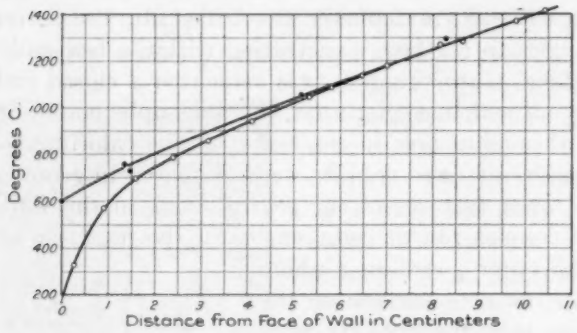

FIG. 4.—Comparison between fixed and sliding couple.

A Lateral Flow of Heat in the Walls

The conductivity results obtained with the preceding apparatus were in general disagreement with the results of other investigators in that the conductivity for nearly every material was constant over the whole temperature range. It was suspected that this might be caused by a lateral flow of heat in the wall, even with the thorough system of guard rings used. To determine this, temperature readings were

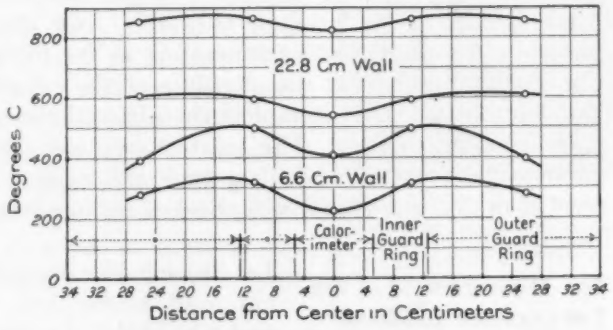

FIG. 5.—Lateral temperature gradient in wall.

taken in the wall in a plane parallel to the cool face in a 22.8- and a 6.35-inch wall.

The results are shown in Fig. 5.

The curves indicate clearly that there is a marked lateral flow of heat in both cases in the region of the calorimeter which should easily account for the straight line temperature gradient found. If we consider a cylinder the diameter of the calorimeter, with a length equal to the thickness of the wall, we shall have the following ratios of the area of the end of the cylinder to the side of the cylinder for three thicknesses of the wall.

TABLE I

Wall thickness (cm.)	6.35	11.4	22.8
Ratio of area of end and side of cylinder	2.36	4.23	8.46

Considering the case of the 22.8 cm. wall there was a lateral temperature gradient of 13° per cm. while for the 6.35 cm. wall there was a temperature gradient of 20° per cm. If these figures are then multiplied by the corresponding area ratios given above we shall obtain 154° and 47° per cm. temperature gradients which are respectively 220 and 63% of the temperature gradient perpendicular to the face of the wall. These percentages, therefore, represent the error which may be present in the quantity of heat flow. The problem is not simple of calculation because the temperature gradient is affected by the error in heat flow and to some extent, reduces this error. It seems impossible at present to express mathematically the error introduced into the conductivity by these factors.

Conductivity measurements with the same type of fire brick were made with a 22.8, 11.4, and 6.35 cm. wall and a 22.8 cm. wall with insulation. Runs were also made on the same brick at high and low temperatures, also with the calorimeter alone and with the calorimeter and inner guard ring together as the calorimeter. The average conductivity values for these different cases are given in Table II.

TABLE II

Wall Thickness	Temperature	Insulation	Calorimeter	Average Conductivity
22.8	high	non	single	.0050
11.4	"	"	"	.0048
6.35	"	"	"	.0033
22.8	"	11.4	"	.0041
11.4	"	non	"	.0043
11.4	low	"	"	.0044
11.4	high	"	"	.0047
11.4	"	"	cal. inner ring	.0045

It will be noticed that the conductivity figure decreases with the wall thickness so that the value for the thinnest wall is approximately equal to the more precise value obtained later for this brick. It may therefore, be assumed that there is an increasingly large error due to lateral flow of heat as the wall thickness is increased. There is a smaller

difference between the value for the 11.4 cm. and the 22.8 cm. wall than between the thinner walls and this is probably due to the fact that the thicker wall approximates the walls of the furnace itself and therefore somewhat limits the lateral heat flow.

The insulation of the thicker wall reduces the conductivity figure to nearly its true value due to the fact that the section of the test wall is then identical with the remainder of the furnace walls which considerably reduces the lateral heat flow.

Two identical tests were made, one with a high furnace temperature and the other with a low furnace temperature. The results for the conductivity over equal temperature ranges will seem to be nearly identical.

A run was made and the conductivity computed by the heat flow measured by the calorimeter alone, and the conductivity again figured for the calorimeter and inner guard ring which were maintained at the same temperature, forming in effect a large calorimeter. As would be expected, the conductivity value is somewhat lower for the larger calorimeter because the ratio of calorimeter area to the side area of the cylinder is decreased.

Other Errors There are numerous less serious errors to be considered in the measurement of thermal conductivity. For example, it is necessary to have both the outside of the wall and the inner face of the calorimeter in close and even contact in order to provide a lineal flow of heat into the calorimeter. This condition is difficult to attain because the wall changes its form slightly on heating and the calorimeter, if large, is apt to warp and particles of grit tend to separate the surfaces. This is the reason that it is usually desirable to provide a somewhat yielding high resistant material between the calorimeter and the wall, such as asbestos paper, not only to even up the temperatures on the cold face of the wall but also to provide a more even contact for the calorimeter surface. When the calorimeter is large it is necessary to divide it up into smaller sections connected together with rubber tubes which can be held separately against the wall by springs.

Another error in conductivity tests at high temperatures is the contamination of the platinum couples by contact with the brick and the furnace gases in the prolonged heating. Frequent calibrations are necessary to obtain accurate temperature measurements.

Gas Pressures It is well known that the heat flow through the average refractory material is greatly dependent upon the pressure difference between the furnace and the atmosphere. With high gas pressures the passage of the gas through the pores of the refractory and through some cracks which are bound to open up,

conducts a large amount of heat through the wall. On the other hand, if the pressure in the furnace is below atmospheric, cold air is drawn through the wall and tends to retard the flow of heat. This effect is of course, much more pronounced on a large wall with numerous cracks than for specimens made in a single piece and a dense specimen would show the effect less than a porous specimen. Therefore, in all conductivity tests, care should be taken to maintain atmospheric pressure on the hot side of the specimen.

Recommendations These tests indicate that in order to obtain reasonably accurate values of thermal conductivity at high temperatures, it will be necessary to construct a furnace in such a manner that the lateral flow of heat can be kept down to a minimum. It also seems necessary to provide some satisfactory means for protecting thermocouples, which should pass at right angles to the direction of heat flow, against the action of the furnace gases and the hot brick. In fact, if temperatures above 1350°C are to be attempted, the readings near the hot surface of the specimen should be made with an optical pyrometer and the furnace should be provided with regulation so that the pressure may be kept close to atmospheric during the run.

The test described above has a further disadvantage of being costly in fuel and time as well as requiring about forty standard-sized bricks for making up a single wall. Where it is necessary to measure the thermal conductivity with a small amount of experimental material, this method cannot well be used.

III. Final Design of Apparatus

After a considerable amount of experimenting, a conductivity furnace was designed which proved to be relatively satisfactory. This furnace is shown in Figs. 6 and 7.

The Furnace A specimen, *A*, is made in the form of a cylinder 10.8 cm. in diameter and 22.8 cm. long, resting on a water calorimeter, *B*, of the same diameter. This specimen is surrounded by a layer, *C*, of insulation about 1 cm. thick consisting of infusorial earth for the lower temperatures and mullite sand for the higher temperatures. This layer is in turn surrounded by a series of rings each containing an annular passage, *D*. Outside of these rings is a layer of crushed fire brick, *E*, and then a layer of insulation, *F*. A guard ring, *P*, surrounds the calorimeter and supports the ring.

The top of the specimen is heated by a small cylindrical furnace, *G*, surrounded by insulation. Heat is supplied to the furnace by two tangential nozzles connected to a premix blower for gas and air. The exhaust gases are taken up through the stack, *H*, to an exhaust blower

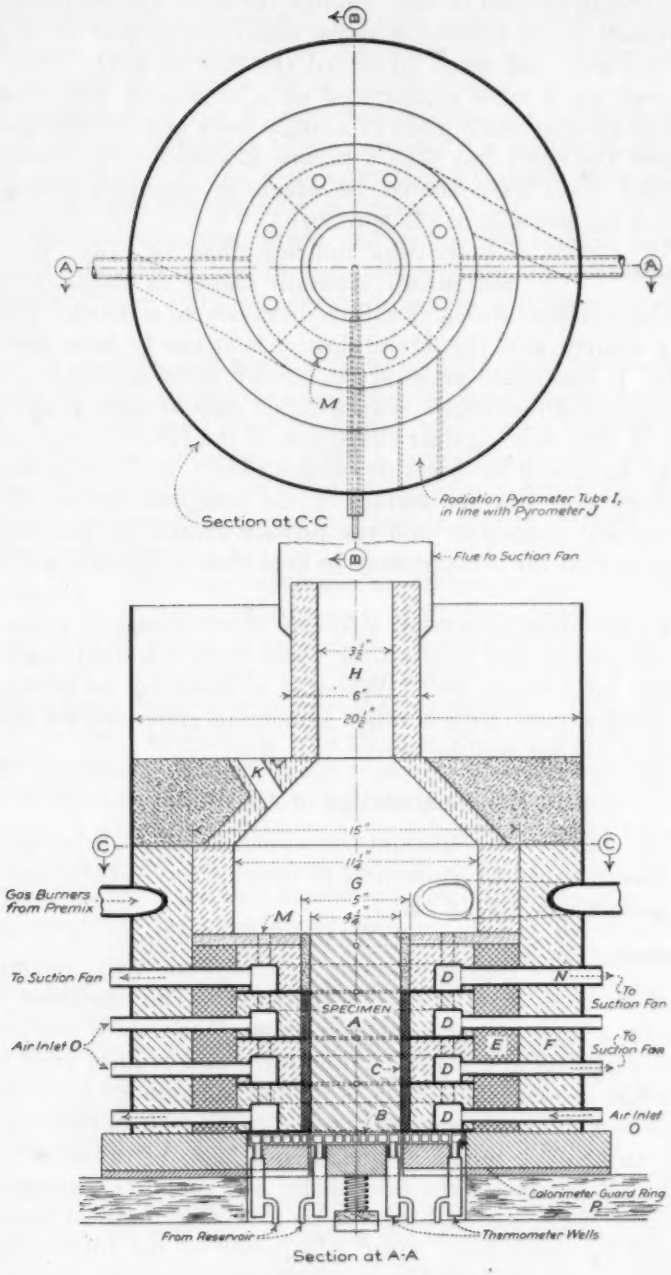

FIG. 6a.—Final design of furnace.

for regulating the pressure in the furnace. A sight tube, *I*, in the side of the furnace is in line with the radiation pyrometer, *J*, for recording the temperature. Another sight tube, *K*, is provided for taking the temperature of the center of the specimen.

The temperature gradient in the specimen is measured through the holes, *L*, which pass through the furnace in porcelain tubes and which line up with horizontal holes, penetrating to the center of the specimen. These holes are only .5 cm. in diameter and therefore will have practically no effect on the heat flow. The low temperatures can be read by inserting a thermocouple to any desired distance in the specimen and the higher temperatures can be read directly with an optical pyrometer.

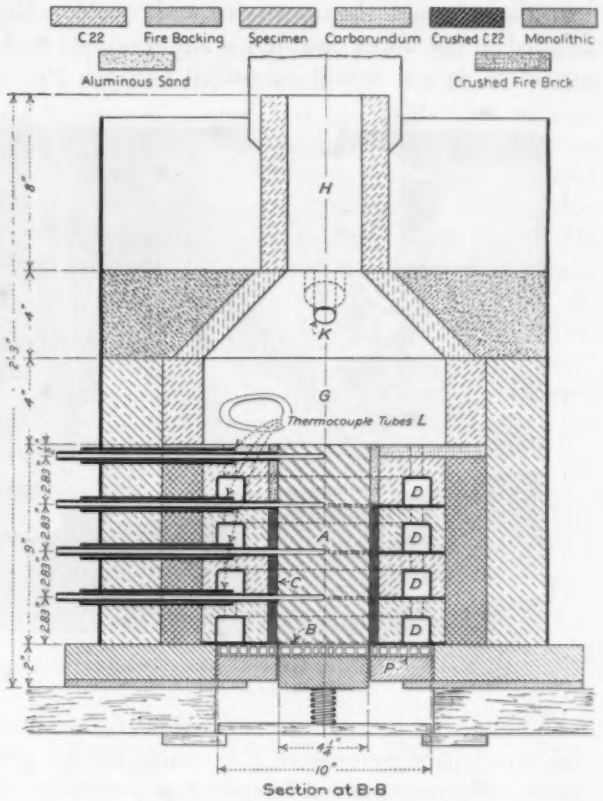

FIG. 6*b*.—Final design of furnace.

The object of the passages, *D*, in the rings around the specimen is to prevent any lateral flow of heat from or into the specimen. By adjusting the temperature of these rings, it is possible to obtain the same temperature at the center and outside of the specimen as measured through the holes, *L*. If this condition is fulfilled there can be no lateral heat flow. The upper ring is connected to the furnace chamber by the ports, *M*, so that furnace gases can be pulled down into this ring and out through the exhaust tubes, *N*, by a small suction fan thus heating the upper ring to any desired degree up to the temperature of the furnace. If these rings are made of high conducting

material such as silicon carbide, the heat is conducted more rapidly downward through the rings than through the specimen; therefore to keep the lower rings at such a temperature as to prevent lateral flow, cold air is blown in through the passages, *O*, and out through similar passages to affect any desired degree of cooling. If the specimen, *A*, were an insulating brick, for example, only a small amount of gas would be pulled through the upper ring and considerable cooling air would be applied to the lower ring, but if the specimen had a high conductivity, considerable gas would be pulled through the upper ring. As it is

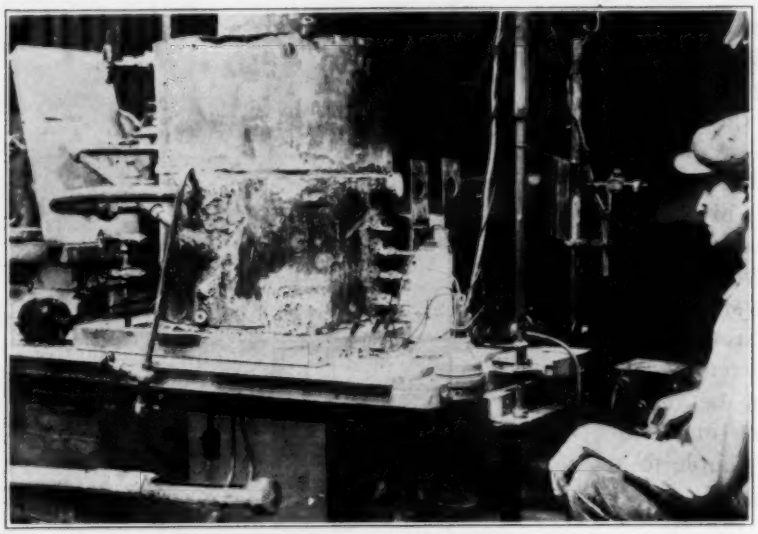

FIG. 7.—General view of final type of furnace.

found essential to maintain a constant furnace temperature during the run, a radiation pyrometer, *J*, is connected to a recording potentiometer which operates a special temperature controller designed for this work. This maintains the temperature within the furnace to $\pm 10°C$. If the runs are made at low temperatures, the radiation pyrometer is replaced by a thermocouple.

A specimen is most readily made up by grinding the face of two bricks, clamping them together, and grinding the cylinder with this joint as a diameter. The bricks are separated and grooves cut in one of them to form the temperature measuring holes. The bricks are then cemented together with a thin slip of the same material as the brick and usually a thermocouple is placed in the joint at the bottom of the specimen to obtain a low temperature reading. The specimen is dried and the lower end is washed over with a very fine-grained cement and

rubbed down on a flat plate to give a true surface to rest on the sheet of asbestos paper which is placed between the specimen and the calorimeter. The holes in the specimen are lined up with the holes in the furnace and the insulating material is poured between the specimen and the rings until level with the top of the specimen where a little cement is added to keep the flame from blowing out the particles.

Method of Making a Run

The furnace is started up and brought rapidly to the desired temperature at which point the controller can be turned on to maintain it. In about twelve hours, an approximate balance is reached and the inside and the outside of the specimen is balanced up by adjusting the flow through the rings. Also the average temperature of the calorimeter and the guard ring is made the same. The furnace is then allowed to run another twelve to twenty-four hours until the temperatures are completely balanced at all points and then two, one-half hour runs are made, recording the temperatures of the specimen through sight tubes, K, the temperatures along the axis of the specimen, the water temperatures, and the quantity of water flow.

The data for a typical run is shown in Table III. It will be seen that the temperatures of the inside and outside of the specimen are not appreciably different at any point measured.

TABLE III

	Calorimeter Degrees C		Ring Degrees C			
Time	In	Out	In	Out	Time of run min.	Wt. of water gms.
10:35	8.35	16.05	8.30	16.14		
10:42	8.30	16.00	"	16.15		
10:50	8.40	16.25	8.40	16.20	15	2842
11:00	"	16.28	"	16.25		
11:07	"	16.40	8.45	16.30		
11:15	"	16.50	"	16.32	15	2748

			Temp. No. 2		Temp. No. 3		Temp. No 4		
Time	Top temp.	Temp. No. 1	Center	Surface	Center	Surface	Center	Surface	Temp. No. 5
10:35	1455°C*	1318°C*	1075°C*	1072°C	765°C	765°C	425°C	428°C	185°C
			1078						
10:50	1455*	1318	1075	1072	765	765	425	428	185
			1078						

*Readings taken with optical pyrometer.

$t_1 = 7.75°C$ (temp. diff. of calorimeter water)

$t_1 \times 2842$ gms. $= 22100$ calories

$t_2 = 7.79°C$

$t_2 \times 2748$ gms. $= 22000$ calories

Av. heat $= 22050$ calories

$$\text{Heat flow} = \frac{\text{calories}}{\text{area} \times \text{time}} = \frac{22050}{91.6 \text{ sq. cms.} \times 900 \text{ secs.}}$$

$$= .267 \text{ cal/cm}^2\text{/sec.}$$

The couples used for measuring the temperature were carefully calibrated at frequent intervals but it was found that they did not change, which was due to the fact that they were inserted in the holes for only a short time. The optical pyrometer was also frequently checked not only against another standard instrument but by taking readings both with the optical pyrometer and the thermocouples in the upper holes of the specimen. It is believed that the temperature measurements are precise to better than $\pm 10°$ C.

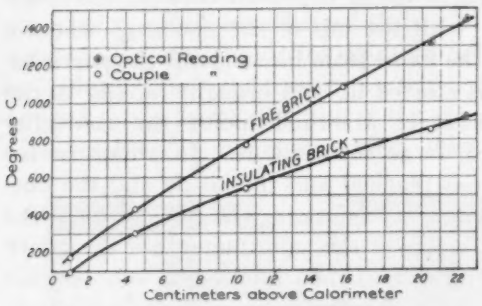

FIG. 8.—Temperature gradient curves.

In Fig. 8 there is shown a curve of temperature through an insulating brick and a fire brick. It will be noted that the curves are slightly convex upwards and that the temperature points lie fairly well on a smooth curve. The slight irregularities are due probably to lack of perfect balance between the inside and the outside of the specimen.

Precision of the Measurements It is very difficult to determine the precision of these tests. Although the values were usually checked on a second specimen within 5%, there is no certainty that a much larger constant error may not exist due to uneven heat flow, particularly in the specimens with a high conductivity. Taking everything into consideration, the results should have at least the following precision:

TABLE IV

Specimen	Per cent Particular Values	Per cent Mean Value
Silicon carbide	±40	±25
Magnesite	±30	±20
Fused alumina and other refractories	±20	±15

Conductivity Values It should be noticed that all the values of thermal conductivity given in this report are particular values for a definite temperature and are not averages over a temperature interval. If it is desired to find the mean conductivity between two temperatures, it can be done most accurately by measuring the area under the conductivity curve between the two temperature limits and dividing this area by the temperature interval. In most cases, however, sufficiently close approximation can be made of the mean value by a visual inspection of the curve.

Units Thermal conductivity has probably been expressed in more types of units than any other measurement. I have noticed at least thirteen kinds of units published and quite probably there are more. However, there are a few commonly used units that are becoming more or less standardized for this type of work. In this report the centimeter-second-calory unit is used as this is perhaps the most universal unit. It is more precise, however, to use the Joule instead of the calory, as the latter must be defined, whereas the former is a definite unit. The engineering units used by refrigerating engineers are usually expressed on a 24-hour basis rather than a one-hour basis as it more nearly conforms to their tests and operations.

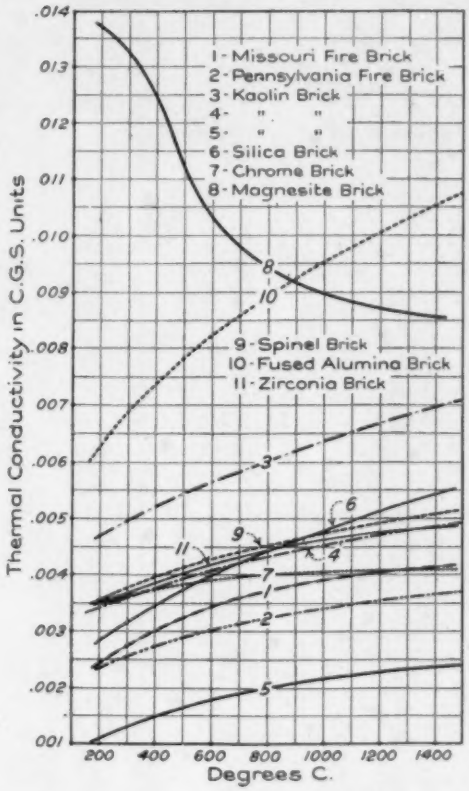

FIG. 9.—Thermal conductivity of various refractories.

In the table below there is given a list of the more common units and factors for converting the centimeter-second-calory unit into any other.

TABLE V

Length	Area	Time	Temp.	Heat Unit Factor	
centimeter	centimeter²	second	°C	gram calory	1
"	"	"	C	Joule	4.18
inch	foot²	hour	F	Brit. Thermal unit	2900
"	"	24 hrs.	F	" " "	69600
foot	"	hour	F	" " "	233
"	"	24 hrs.	F	" " "	5800

IV. Conductivity of Various Materials

A number of representative specimens of refractory brick was tested according to the preceding method to determine their thermal conductivity up to temperatures of approximately 1600°C. The values for the various specimens are plotted in Figs. 9 and 10. No experimental

points are shown as these curves are derived from the temperature gradient curves which were faired curves through the experimental values.

The density and porosity of these materials were found by the water method. Small pieces were weighed dry, then boiled in water for two hours, and allowed to soak for twelve hours. They were then weighed in water and in air. The porosity, apparent density, and bulk density were found by Purdy's formulas:

$$\text{Porosity} = \frac{W-D}{W-A} \times 100$$

$$\text{Bulk density} = \frac{D}{W-A} \text{ gm/cc}$$

$$\text{Apparent density} = \frac{D}{D-A} \text{ gm/cc}$$

where

W = weight saturated in water
A = weight saturated in air
D = weight dry

The values are given in Table VI. It is evident that this method does not include the closed pore space, but in most cases this is small as the apparent density is close to the true density.

TABLE VI

Specimen Number	Kind of Brick	Porosity per cent	Apparent density	Bulk density
1	Missouri fire brick	18.4	2.64	2.15
2	Penn. fire brick	26.7	2.59	1.90
3	Kaolin brick	10.8	2.66	2.36
4	Kaolin brick	23.2	2.68	2.10
5	Kaolin brick	49.1	2.50	1.27
6	Silica brick	30.4	2.34	1.64
7	Chrome brick	30.5	3.94	2.74
8	Magnesite brick	31.6	3.54	2.42
9	Spinel brick	36.3	3.51	2.23
10	Fused alumina brick	21.3	3.67	2.90
11	Zirconia brick	29.5	4.87	3.43
12	Silicon-carbide brick	35.3	3.19	2.06

A chemical analysis of all the specimens is not available but in Table VII below are given the compositions of some of them.

TABLE VII

Specimen Number	1	2	3–5	6	9	11
SiO_2	53.12	54.16	52.02	97.00		27.26
Al_2O_3	43.30	38.84	45.92		65	7.75
FeO_3	2.48	2.70	1.51			1.60
TiO		2.72	.35			
CaO	0.64	0.10	none		26	.04
MgO	0.46	1.14				
Alkalis	0.15		trace			
ZrO_3						
Sulphates		0.20				60.44

No. 1, Missouri Fire Brick This brick is a high-grade Missouri brick which was carefully selected to represent a medium firing. The thermal conductivity starts at a value of .0024 at 200°C and rises rapidly at first and then more slowly to .0041 at 1400°C.

No. 2, Pennsylvania Fire Brick This is a well known Pennsylvania brick, which, although well fired is considerably more porous than the preceding specimen. As we should expect, the conductivity is lower, although there is little difference at the lower temperatures. The curve is of about the same shape as for specimen No. 1.

No. 3, Kaolin Brick This specimen was made of a Southern sedimentary kaolin in such a way as to produce a minimum porosity. This was done by mixing 65% of 20-mesh prefired grog and 35% of raw clay, and firing to 1575°C for four hours. The conductivity curve for this specimen is the same shape as the others, but considerably higher, reaching a value of .00686 at 1400°C.

No. 4, Kaolin Brick This specimen was made of the same material as the preceding, but due to the use of 4-mesh grog the porosity was increased to 23.2. The conductivity curve, as would be expected, is somewhat lower than for specimen No. 3, reaching a value of .0050 at 1600°C. It will be noted that the kaolin brick has a conductivity about one-third higher than fireclay brick of the same porosity.

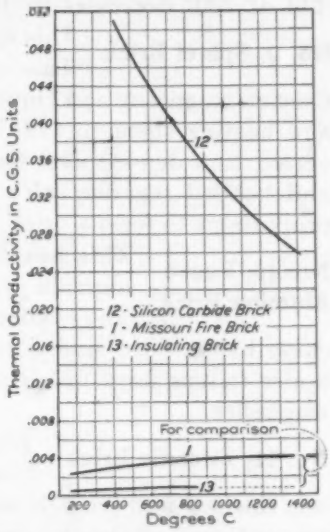

FIG. 10.—Thermal conductivity of silicon-carbide bricks.

No. 5, Kaolin Brick This specimen was also made of the same material as specimen No. 3 but the porosity was increased to 49.1%. The conductivity is quite low, bringing it in the class of insulating bricks. The shape of the conductivity curve is the same as for the other specimens.

No. 6, Silica Brick This was a commercial silica brick from the Pennsylvania region. At low temperatures the conductivity is little higher than the fireclay bricks but at 1400°C it conducts nearly 50% more. The conductivity curve is different from the preceding ones in being much steeper and having a smaller curvature.

No. 7, Chrome Brick This was a commercial brick. The conductivity is somewhat higher than the fireclay bricks at low temperatures but at 1400°C is about the same. The conductivity curve has a very low slope at the higher temperatures.

No. 8, Magnesite Brick This specimen was a commercial magnesite brick of a well-known brand. The conductivity curve is radically different from any of the preceding ones as it shows a decrease in conductivity with the temperature. The value of .014 at 200° decreases to .0085 at 1400°.

No. 9, Spinel Brick This specimen was a special brick made of spinel. This spinel was made up by grinding together Grecian magnesite and Dutch Guiana bauxite in the proper proportions and heating them to 1775°C until the mixture was completely converted to a dense spinel biscuit. This biscuit was crushed into grog and bonded together with raw magnesite and bauxite in the same proportions to form a brick. The brick was then fired at 1750°C.

No. 10, Fused Alumina Brick This specimen was a commercial brick made of fused alumina grog and presumably bonded with fire clay. The conductivity runs up to .0105 at 1400°C and the curve has a shape similar to those for fire bricks. It is interesting to notice that at high temperatures the conductivity is greater than for magnesite.

No. 11, Zirconia Brick This specimen was a special brick made from a South American baddeleyite ore. This ore was calcined and crushed into grog and bonded with some fine ground ore and pressed into bricks. They were then fired at 1650°C. The conductivity is about one-third greater than fireclay bricks and not very low as sometimes stated.

No. 12, Silicon-Carbide Brick This was a commercial recrystallized silicon-carbide brick. The conductivity is far greater than that of any other specimens tested. A value of .048 was obtained at 500°C but the conductivity falls rapidly with an increase in temperature until a value of .0245 is reached at 1500°C. At high temperatures these tests show that silicon carbide has a conductivity only twice that of fused alumina, while at low temperatures the ratio is about six to one.

V. Discussion of Results

In Table VIII are summarized the thermal conductivity values obtained in these tests together with values obtained by others.

It is evident at once upon examining the preceding table that the results from different experimenters are quite divergent. In comparison with the results presented here, some of the values are higher, some are

TABLE VIII

No.	Material	Temperature °C 200	400	600	800	1000	1200	1400	1500	Authority
1	Missouri fire brick	.0024	.0030	.0035	.0037	.0039	.0041	.0042		Norton
2	Penn. " "	.0024	.0027	.0030	.0032	.0034	.0036	.0037		"
3	Kaolin " "	.0047	.0052	.0056	.0060	.0064	.0067	.0070		"
4	" " "	.0034	.0038	.0041	.0043	.0045	.0047	.0048	.0050	"
5	" " "	.0011	.0015	.0018	.0020	.0022	.0023	.0024		"
6	Silica " "	.0028	.0035	.0040	.0044	.0048	.0052	.0054		"
7	Chrome " "	.0034	.0037	.0039	.0040	.0040	.0041	.0041		"
8	Magnesite " "	.0137	.0125	.0103	.0095	.0090	.0087	.0085		"
9	Spinel " "	.0036	.0040	.0042	.0045	.0047	.0049	.0051		"
10	Fused alumina	.0062	.0074	.0082	.0089	.0095	.0101	.0105		"
11	Zirconia brick	.0035	.0039	.0042	.0044	.0046	.0048	.0049		"
12	Silicon carbide			.0440	.0380	.0330	.0290	.0260		"
	Fire brick	.0019	.0022	.0026	.0030	.0033				Dudley
	Silica "	.0024	.0029	.0033	.0038	.0043				"
	Magnesite brick	.034	.034	.034	.034	.034				"
	Silica "			.00087		.00127				Green
	Fire "				.00135	.00206				"
	Magnesite			.00285		.00252				"
	Fire brick			.00400						Wologdine
	" "		.00251							Goerens
	" "				.0033					Dougill, etc.
	" "			.00117						Heyn, etc.
	" "		.0023	.0025	.0027	.0029	.0030			Hartmann and Westmont
	Silicon carbide	.040	.040	.040	.040	.040	.040			Hartmann and Westmont
	Silica brick	.0049	.0057	.0053	.0053					Tadokoro
	Chrome "	.0056	.0060	.0058	.0051					"
	Fire "	.0028	.0036	.0037	.0037					"
	Magnesite brick	.0066	.0049	.0044	.0038					"

lower, and a few are in good agreement. While part of this difference is due to differences in materials, only a small part of the discrepancy can be accounted for in this way. For example, the conductivity of magnesite brick is reported by Green and Tadokoro as only 10 or 15% of the values found by other experimenters. Again magnesite is variously found to have an increasing, constant, and decreasing conductivity with increase in temperature. While not enough precise work has been done on conductivity to state definitely which values are correct, it is certain that many of them must be greatly in error.

The thermal conductivity of a particular material is dependent on two factors: the conductivity of the homogeneous substance composing the material, and the state of porosity or sub-division of this substance. This is shown by the curves in Fig. 11 where the thermal conductivity of kaolin is plotted against the porosity for three specimens. The curves are approximately straight lines and may be extrapolated to give the conductivity at zero porosity, a state that is extremely difficult to attain practically.

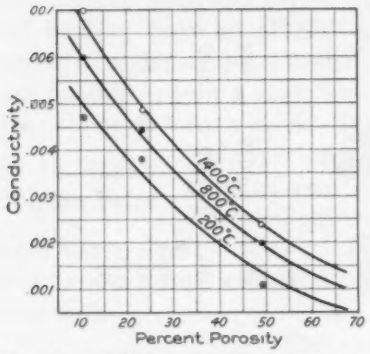

FIG. 11.—Relation of conductivity to porosity.

The range of conductivity of the kaolin specimens is approximately four to one and may be extended still more. This illustrates the large influence of condition of material on conductivity. It should not be concluded that porosity has the sole influence on conductivity for undoubtedly the size and shape of the pores are an important factor.

The thermal conductivity is greatly influenced by the temperature as shown in Figs. 9 and 10. In most cases, the conductivity increases with the temperature, rapidly at low temperatures and more slowly at high temperatures. Magnesite and silicon carbide, however, show the anomalous property of decreasing conductivity with increasing temperature.

If homogeneous materials are considered, it would seem probable that the temperature coefficient of the thermal conductivity might be either positive or negative as is the case with metals. When a porous material is considered, it would be expected that the conductivity would increase rapidly at high temperatures due to the influence of radiation across the pore spaces. These tests, however, do not indicate a more rapid increase in conductivity with temperature in the porous than in the dense specimens and this is probably due to the fact that heat

transfer by radiation does not become important at temperatures up to 1500°C.

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A STUDY OF THE EFFECT OF THE SUBSTITUTION OF CALCINED BALL CLAY FOR NONPLASTIC IN PORCELAIN AND TALC BODIES[1]

By A. S. Watts, R. M. King, and H. G. Fisk

ABSTRACT

It has been the purpose of this study to determine the effect of the substitution of calcined ball clay for flint in certain type bodies. Complete data on the physical properties of these bodies has been obtained, including electrical resistivity up to 980°C. A substitution of calcined ball clay for a portion of the talc in a type talc body has also been made.

Introduction

Many porcelain bodies owe their desirable properties to the mullite which is developed in them in the firing process. This mullite may be cryptocrystalline and only visible under the highest power of the microscope, as indeed it is in most cases, but nevertheless it is present in most porcelains which contain the alumina and silica necessary for its formation. It is a matter of considerable importance to determine what clays tend to form mullite most readily in the fired body, and whether ball clays with their comparatively high alkali content will form a larger amount of mullite than kaolins, especially at commercial firing temperatures. Also whether by substituting for flint, or other nonplastic, a finely ground vitrified ball clay, with a cryptocrystalline development of mullite, a body can be produced which will have more desirable properties.

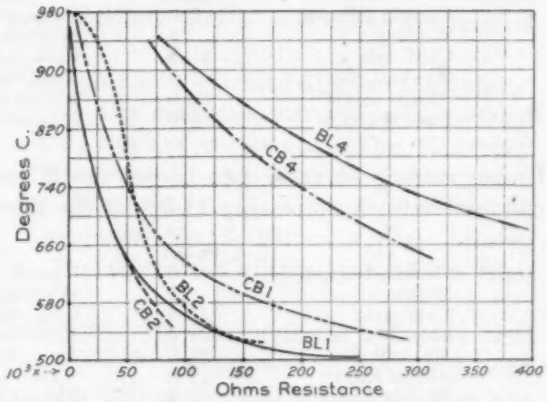

Fig. 1.—Electrical resistivity of bodies over the interval 500 to t°C.

Bodies and Materials

Normal Type Porcelain

Two normal blank bodies were made up, the first one with raw Kentucky ball clay and the second with raw Tennessee ball clay. Their compositions were as follows:

[1] Received October 19, 1926.

BL1	Per cent	BL2	Per cent
Canada feldspar	30.0	Canada feldspar	30.0
Ky. ball clay	40.0	Tenn. ball clay	40.0
Flint	30.0	Flint	30.0

Corresponding to these two bodies the following were made up with calcined ball clay replacing flint as nonplastic.

CB1	Per cent	CB2	Per cent
Canada feldspar	30.0	Canada feldspar	30.0
Ky. ball clay	40.0	Tenn. ball clay	40.0
Calc. Ky. ball clay	30.0	Calc. Tenn. ball clay	30.0

Normal Talc Bodies Two normal blank talc bodies were made up, the first one with raw Kentucky ball clay and the second with raw Tennessee ball clay. Their compositions were as follows:

BL3	Per cent	BL4	Per cent
Canada feldspar	7.0	Canada feldspar	7.0
Whiting	.5	Whiting	.5
Calif. talc	47.5	Calif. talc	47.5
Ky. ball clay	25.0	Tenn. ball clay	25.0
Albian kaolin	10.0	Albian kaolin	10.0
Florida kaolin	10.0	Florida kaolin	10.0

Corresponding to these two bodies the following were made up with calcined ball clay replacing 25.0% of the talc.

CB3	Per cent	CB4	Per cent
Canada feldspar	7.0	Canada feldspar	7.0
Whiting	.5	Whiting	.5
Calif. talc	22.5	Calif. talc	22.5
Calc. Ky. ball clay	25.0	Calc. Tenn. ball clay	25.0
Ky. ball clay	25.0	Tenn. ball clay	25.0
Albian kaolin	10.0	Albian kaolin	10.0
Florida kaolin	10.0	Florida kaolin	10.0

Normal Chemical Porcelain Two normal blank chemical porcelain bodies were made up, the first with raw Kentucky ball clay and the second with raw Tennessee ball clay. These bodies contained calcined kaolin as nonplastic. Their compositions were as follows:

BL5	Per cent	BL6	Per cent
Canada feldspar	7.0	Canada feldspar	7.0
Whiting	1.5	Whiting	1.5
Magnesium carbonate	1.5	Magnesium carbonate	1.5
Kentucky ball clay	35.0	Tenn. ball clay	35.0
Calcined kaolin	35.0	Calcined kaolin	35.0
Albian kaolin	10.0	Albian kaolin	10.0
Florida kaolin	10.0	Florida kaolin	10.0

Corresponding to these two the following two were made up with calcined ball clay replacing calcined kaolin.

CB5	Per cent	CB6	Per cent
Canada feldspar	7.0	Canada feldspar	7.0
Whiting	1.5	Whiting	1.5
Magnesium carbonate	1.5	Magnesium carbonate	1.5
Ky. ball clay	35.0	Tenn. ball clay	35.0
Calc. Ky. ball clay	35.0	Calc. Tenn. ball clay	35.0
Albian kaolin	10.0	Albian kaolin	10.0
Florida kaolin	10.0	Florida kaolin	10.0

The following data are relative to the materials used in the above bodies:

Chemical Analysis

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Loss on ignition	Total
Flint	99.81	0.17	0.014	none	none				99.99
Feldspar	64.21	20.10	.07	.14	.09	2.08	13.17	0.10	99.96
Talc	60.53	0.46	1.20	0.70	30.99	none	none	5.67	99.68

Microscopic examination of the feldspar showed that it consisted largely of microcline with some albite and a very small amount of free quartz.

The calcined kaolin was Georgia kaolin calcined at cone 13 obtained from the A. C. Spark Plug Co. The magnesia was the light calcined variety. The whiting was C.P. calcium carbonate. The Kentucky ball clay was that known as Kentucky No. 4 (Kentucky Construction and Improvement Company, Mayfield, Ky.). The Tennessee ball clay was that known as Tennessee No. 5. (Mandle Clay Mining Company, St. Louis, Mo.). The talc was California talc from Inyo County.

Preparation of the Calcined Ball Clay

Approximately 30 lbs. of each ball clay was run through rolls and crushed to pass an 8-mesh screen. One-half of this amount of each clay was mixed with sufficient water to give a good stiff-mud consistency and thoroughly pugged in a day mixer until uniform. The clays were then extruded into $\frac{3}{8}$-inch rods from 6 to 18 inches in length. Moisture content was determined on these rods immediately after extruding, and it was found that Kentucky ball clay rods contained 38.0% and the Tennessee ball clay rods contained 39.0% water. The rods were placed in large oval saggers in criss-cross manner and allowed to dry in the room over night. They were placed in a drier at 60°C on the following day.

Preliminary vitrification tests were made upon the rods by firing them in a small muffle furnace. From these tests it was found that almost complete vitrification was obtained at about cone 12. The clay rods were set in a kiln with the Tennessee ball clay rods above the Kentucky ball clay rods. They were protected from the gas flame by saggers. The Tennessee ball clay rods received a heat treatment equal

to cone 13 whereas that of the Kentucky ball clay rods was equal to cone 12.

Five absorption determinations were run on fractured pieces broken from the rods of each clay, the average for Tennessee ball at cone 13 being 0.329% and for Kentucky ball at cone 12 being 0.176%.

The calcined ball clays thus prepared were ground dry in ball mills to pass a 200-mesh screen. Screen analysis on the ground clays were as follows:

Calcined Ky. Ball Clay		Calcined Tenn. Ball Clay	
Per cent		Per cent	
1.8	on 260-mesh	6.5	on 260-mesh
5.6	on 300-mesh	9.5	on 300-mesh
92.6	300-mesh to fines	84.0	300-mesh to fines

Forming of the Bodies

The method of forming the bodies for the various tests was the same in each case. 600-gram batches were weighed into gallon capacity ball mills and 600 cc of water added to each batch. These quantities produced a slip in each case. After mixing each batch was allowed to grind for two hours. The ground slips were screened through 100-mesh screens into shallow pans and de-watered by evaporation at 40°C.

When dry the batches were pulverized sufficiently to pass a 10-mesh screen and introduced into gallon crocks with 100 cc of water sprayed uniformly through the material. The batches thus moistened were covered with damp cloths and allowed to age for 48 hours.

After aging each body was screened through a fine-wired 12-mesh screen and mixed. In this condition they were ready for dry pressing.

For cross-breaking, spall, and absorption tests bars 1 x $1\frac{1}{2}$ x 4 inches were pressed in a squeeze out mold. The bars were immediately marked for drying shrinkage and weighed for water content. For electrical tests and impact resistance small bushings of each body were dry pressed. These bushings were $\frac{1}{4}$ inch thick, their outside diameter was $\frac{3}{4}$ inch, and the hole through them was $\frac{1}{4}$ inch in diameter.

Firing

Preliminary firing tests were made upon the small bushings, and absorptions run upon these to determine the proper temperature at which to fire the various bars and bushings for physical tests. In Table I, data relative to drying shrinkage, water content, fired properties, and physical tests exclusive of electrical resistivity are given for the different bodies. In Table II, the electrical resistivities from 500 to 990°C are given. The electrical resistivities were determined by the method of King.[1] The accompanying graphs show the relation of temperature to resistivity for some of the bodies.

[1] R. M. King, *Jour. Amer. Ceram. Soc.*, 9 [6] 343–50 (1926).

Discussion of Results

From a study of the tables the following conclusions may be drawn:

Modulus of Rupture (*a*) Substitution of calcined ball clay for flint in the normal porcelain body gives increased modulus of rupture. (*b*) There is no advantage of calcined ball clay substitution over talc in talc bodies, on modulus of rupture. (*c*) There is no advantage in substituting calcined ball clay for calcined kaolin in a chemical porcelain body for modulus of rupture.

Resistance to Impact (*a*) Replacement of calcined ball clay for calcined kaolin in a chemical porcelain body appears to improve it for resistance to impact. (*b*) There is no improvement in replacing calcined ball clay for flint in a normal body on this test. (*c*) The data on this test for the talc bodies is erratic.

Resistance to Heat Shock Replacement of flint by calcined ball clay gives slight improvement in normal porcelain, and in the chemical porcelain body there seems to be a slight improvement, although it is not appreciable. All of the heat shock tests on the talc bodies are very good, although replacing part of the talc by calcined ball clay shows no improvement in this test. The talc bodies are, however, apparently not injured in heat shock resisting qualities by replacing calcined ball clay for a portion of the talc.

TABLE I

DATA ON PORCELAIN AND TALC BODIES
WITH CALCINED BALL CLAY SUBSTITUTED FOR NONPLASTIC

Body No.	Firing Temp. cone	Shrinkage D. F.		Mod. of Rupture lbs. sq. in.	Absorption 24 hrs.	Absorption 100 hrs.	Impact Resist. in lbs.	Heat shock No. quenchings
CB1	13½	2.5	10.8	7500	.36	.56	5.00	6
BL1	13½	2.8	9.0	3100	.41	.50	4.95	5
CB2	13½	3.0	10.3	4320	.36	.36	6.15	3
BL2	13½	2.0	8.2	2330	1.56	1.62	8.70	2
CB3	9½	3.8	13.5	7000	.28	.43	12.10	16
BL3	9½	3.4	12.0	6800	.46	.46	9.10	5
CB4	9½	2.0	12.2	4670	.35	.42	12.4	20
BL4	9½	3.0	13.9	6300	.30	.44	39.9	22
CB5	15½	3.0	14.0	5525	.64	.70	7.5	5
BL5	15½	3.0	16.5	5740	.55	.65	4.5	6
CB6	15½	2.8	14.4	4010	1.18	1.18	7.6	8
BL6	15½	3.0	15.5	4475	.35	.35	4.3	5

Firing Shrinkage In the chemical porcelain body this is reduced by replacing calcined kaolin by calcined ball clay. In the other bodies there is a general increase in firing shrinkage in the calcined ball clay bodies.

Absorption Absorption does not appear to be materially affected in any case.

TABLE II

ELECTRICAL RESISTIVITY 10^3 OHMS

T° C	500	523	554	567	590	615	640	665	687	713	739	762	787	812	837	862	887	913	940	963	990
CB1		296	238		161	119	97	81	74	65	55	49	37	36	32	25	20	15	14	88	6
BL1	230	155	120	93	79	68	57	49	39	32	27	24	20	17	16	16	10	9	6	4	3
CB2					65	61	55	47		35	30	24	17	18	13	10	9	7	6	4	3
BL2		167	104	89	87	82	82	76	68	61	56	52	49	49	45	38	30	29	228	15	6
CB3										370	347	274	210	188	163	134	118	95	86	86	78
BL3								610	422	347	318	310	308	283	239	191	186	208	208	214	208
CB4								560	290	257	257	197	190	171	148	115	113	102	92	73	
BL4								530	397	397	342	305	267	267	226	182	160	114	106	100	75
CB5					607	516	455	343	314	512	239	198	114	102	94	91	221		221	186	113
BL5					637		439	362	332	292	244	216	199	193	193	278	329	321	271	222	198
CB6					577	436	328	275	265	195	159	131	123	107	94	81	86	66	57	38	32
BL5							478			330	273	216	128	115	93	85	72	72	62	45	39

Electrical Resistivity

Tennessee ball clay, calcined, is apparently more reliable in regard to electrical resistivity properties than calcined Kentucky ball clay, and although calcined ball clay substitution has not improved the electrical resistivity except in the case of the normal body BL1. The behavior of the bodies containing Tennessee ball clays is never erratic while in the case of the bodies made with Kentucky ball clay it is erratic in the talc bodies and the chemical porcelain.

From the above study it appears that in general there is no advantage in the use of ball clay in fired porcelain bodies except in certain special cases. In other words the only justification for the use of ball clay in such bodies is that it imparts the workable properties necessary to the formation of the bodies, and that in general as little as possible should be used.

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A LABORATORY PROCEDURE FOR DETERMINING THE DRYING CHARACTERISTICS OF CLAYS[1]

By Eldridge J. Casselman[2]

ABSTRACT

Directions are given for conducting a test for determining characteristics of clays. The reaction of the clays having good, intermediate, and poor drying qualities is described.

Clays are known to differ enormously in the ease with which they may safely be dried.[3] The drying properties of clays are especially important in the case of molded shapes. The drying expense becomes larger as the difficulty of drying increases.

When substituting one new clay for another, it is usually possible to predict from laboratory tests the properties which the new clay will impart to the mixture of clays, such as strength, porosity, firing shrinkage, etc. Because of the lack of a suitable laboratory method, however, it has not been possible to foretell with desirable accuracy what difficulties will be encountered in drying.

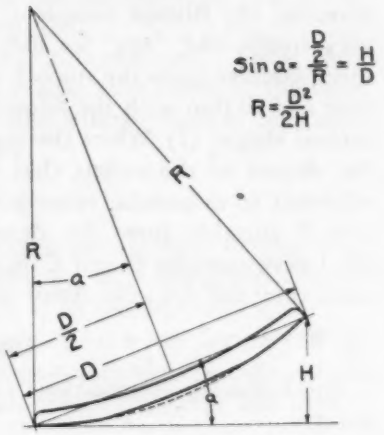

FIG. 1.—Method of measuring the radius of curvature of test-piece B.

The test described in this paper has been devised to determine in the laboratory the relative ease of drying of a clay. It has no particular scientific foundation, such as a relation between colloid content, distribution of particle sizes larger than colloids, or other physical relationships. It has been found, however, to agree with plant practice in the manufacture of refractory shapes, and is published because this agreement indicates that it may be of value in general use.

Directions for Conducting the Test

Equipment Needed

The following equipment or its equivalent is necessary.

1. Plaster of Paris slab, one surface of which has been cast on a flat glass surface. Each slab should be not less

[1] Received November 27, 1926.

[2] Industrial Fellow, Mellon Institute of Industrial Research, Univ. of Pittsburgh, Pittsburgh, Pa.

[3] G. S. Lindsay and W. H. Wadleigh, *Jour. Amer. Ceram. Soc.*, **8**, 677–693 (1925).

than 25 cm wide and 30 cm long, and may be between 0.5 cm and 1.0 cm thick.

2. Three containers, each of about 500 cc capacity, for blunging clay slip. The writer has found porcelain mortars satisfactory.

3. An egg-beater. The type in which oppositely revolving beater arms are driven by a large gear through two smaller gears has proved to be useful in the writer's work.

Method of Testing

The steps in making the test-pieces are: (1) Grind the clay to pass a 40-mesh screen; (2) Take three samples of the ground clay, approximately 25 grams each, designated as *A*, *B*, and *C*; (3) Blunge samples *A* and *B* with just sufficient water[1] to make a slip that will barely flow, and allow to stand for 30 minutes; (4) Blunge sample *C* with enough water[2] to make it flow very freely, and "age" for half an hour before pouring; (5) Pour the three samples upon the smooth surface of the plaster slab;[3] (6) Smooth over and flatten with the finger samples *A* and *B* to avoid drying in a conical shape; (7) When the water of sample *A* has been removed by the plaster to the extent that the upper surface is no longer wet or adherent to a spatula, remove the sample from the plaster and make into a suitable form for determination of the drying shrinkage;[4] (8) Leave samples *B* and *C* on the plaster slab without being touched until they are dry; (9) Allow all the samples to dry naturally in air.

Observations

The following observations are made when the different test-pieces are dry.

(1) Drying shrinkage is determined upon test-piece, *A*, by any of the well-known methods. If volume drying shrinkage is determined, it should be recomputed to linear drying shrinkage, based on the dry dimensions as 100%.

(2) It will be found in the drying of test-piece *B* that the surface against the perfectly smooth plaster is in a slightly warped condition, of a convex character. This surface may be irregular and frequently has a varying radius of curvature at different points. The measurement that is made is the average radius of curvature of this surface at the

[1] The amount of water that is required cannot be given exactly, because clays differ in water requirement.

[2] At least 2.5 cc of water should be used for every gram of clay.

[3] The diameter of the wet pieces, *A* and *B*, upon the plaster should be about 7 to 8 cm.

[4] A cube or sphere is satisfactory for the volume shrinkage determination, or a bar-shaped piece, 15 cm by 1 cm diameter can be used in finding the linear drying shrinkage. The bar form of test is not so accurate as the cube or sphere, because the linear shrinkage in any direction is dependent upon the amount of molding pressure that is used in that direction when the test-piece is made.

edge of the test-piece. One method of making this measurement is to tip the test-piece up on edge by pressure with the fingers, so that the plaster base is tangent to the large surface at its junction with the boundary edge. The diameter of the test-piece and the distance the opposite edge is raised from the plaster are measured as shown in Fig. 1. The radius of curvature is computed from the formula

$$R=\frac{D^2}{2H},$$

wherein D is the diameter of the specimen, H is the height of the raised edge, and R is the radius of curvature. The measurement should be made at several points around the test-piece, so that a fair value for the average radius can be computed.

(3) The amount of cracking in test-piece *C* is observed. These test-pieces generally show either a few large cracks that begin at the edge of the test-piece and extend inward, or else a large number of cracks that check the entire body of the test-piece.

Interpretation

From results obtained in this test in conjunction with drying on a factory scale, it is deduced that the following facts are applicable for interpreting the findings procurable with it in the laboratory.

(1) Clays with good drying properties have (*a*) a low drying shrinkage, 7% or less, on test-piece *A*; (*b*) a large radius of curvature, 40 cm or more, in test-piece *B*; (*c*) a small amount of cracking, less than 5 major cracks, in test-piece *C*.

(2) Clays with poor drying properties have (*a*) a high drying shrinkage, 10% or more on test-piece *A*; (*b*) a short radius of curvature, 20 cm or less, on test-piece *B*; (*c*) a large amount of cracking and checking on test-piece *C*.

(3) Clays with intermediate drying properties have various combinations of these properties.

THE DETERMINATION OF MULLITE IN A PORCELAIN BODY[1]

By T. N. McVay[2]

ABSTRACT

An attempt was made to separate mullite crystals in a porcelain by the use of hydrofluoric, sulphuric, and phosphoric acids. Chemically pure mullite was treated in the same manner. The results of such a separation were not satisfactory.

Introduction

At the present time there is considerable interest shown concerning the quantitative determination of mullite in ceramic bodies. The identification of mullite in porcelain by the use of high power magnification is difficult but not impossible. Its quantitative determination, however, is not feasible at present. The crystals appear as small acicular micro-crystals, often less than 0.0001 mm in thickness, and these are embedded in a glassy matrix from which they have crystallized.

A. Zoellner[3] made a study of porcelain and gave a method for the separation of the mullite from the surrounding glass by means of dilute hydrofluoric acid solutions. Thompson and Vormelker[4] working on refractories used a similar method.

In connection with some research work on porcelains it was decided to attempt a chemical separation of the mullite. The following experiments were undertaken with this in view.

Experimental

A porcelain body of the following composition was selected:

M&M Ivory fat ball clay	20%	Feldspar	30%
H&G A1 English china clay	30	Flint	20

A petrographic examination showed that this body developed mullite when fired to cones 11 and 12.

Hydrofluoric Acid Treatment

The body was crushed to pass 100-mesh and afterwards treated with a 21% hydrofluoric acid solution. In some cases a few drops of sulphuric acid were added to hasten the reaction. All chemical manipulations were made in platinum and the filtrations made in crucibles of the gooch type with platinum sponge in the bottom. It was found necessary to wash and ignite the residue thoroughly on account of certain fluorine

[1] Received October 23, 1926.

[2] Ceramic Engineering Department, University of Illinois, Urbana, Ill.

[3] Zoellner, *Sprechsaal*, **41**, 471–73, 533–36.

[4] F. S. Thompson and H. I. Vormelker, *Jour. Amer. Ceram. Soc.*, 9 [10], 639–40 (1926).

compounds being formed when either the porcelain or pure mullite was attacked.

In order to determine if hydrofluoric acid reacted with mullite a very pure artificial mullite was secured. This had a true specific gravity of 3.08 and an optical examination showed it to be free from glass.

The results of these tests are shown in Table I.

TABLE I

Material	Treatment	Time	% Loss	Residue
Cone 11 Porcelain	Cold HF	24 hrs.	45.0*	Quartz and original porcelain
Cone 11 "	HF+H_2SO_4	" "	98.0	Mainly quartz
Cone 12 "	Cold HF	" "	25.0	Quartz+original porcelain
Cone 12 "	Cold HF	48 "	75.0	Quartz, mullite+original porcelain
Cone 12 "	" HF+H_2SO_4	24 "	94.0	Mainly quartz
Mullite	HF+H_2SO_4	" "	21.0	Mullite showing solution
Mullite	HF	" "	19.0	Mullite showing solution
Ottawa flint	HF	" "	60	Quartz

*Heated but not ignited.

Sulphuric Acid Treatment Two grams of finely pulverized porcelain were boiled in 30 cc of 1 : 1 H_2SO_4 for 5 hours. The loss for the porcelain fired at cone 6 was 0.8% while that fired at cone 12 lost only 0.4%.

Phosphoric Acid Treatment A two-gram sample of porcelain body fired at cone 12 was treated with hot 1 : 1 H_3PO_4 for six hours. The residue after filtration and ignition lost 6.0%. Pure mullite treated in the same manner lost 1%.

Conclusions

The results of the treatment show that hydrofluoric acid attacks mullite, but not as rapidly as it reacts with quartz. While it is true that the higher fired porcelain body was attacked less, it does not necessarily follow that this is due to the mullite content, as there is only a slight change in the amount of mullite present with the one cone increase in firing. Thus it is difficult to conceive how any quantitative data on the amount of mullite can be obtained by these methods, since the residues always contained quartz and in some cases there was only a slight amount of other material present, probably due to the larger size of the quartz grains which allowed them to persist even after the mullite and the glassy matrix had been dissolved.

It is obvious that neither sulphuric nor phosphoric acid as used in the above tests is suitable for the separation of mullite in porcelain bodies.

Acknowledgment

The writer is indebted to C. W. Parmelee for his suggestions in this study and to C. L. Thompson for devising chemical methods and making the chemical analyses and specific gravity determinations. He wishes to thank L. Navias for furnishing the pure mullite crystals.

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THE EFFECT OF CALCINED CYANITE IN PORCELAIN BODIES[1]

By Samuel J. McDowell[2] and Edward J. Vachuska[3]

ABSTRACT

A study was made of the physical properties of porcelain bodies containing varying amounts of calcined cyanite (mullite), feldspar, and flint with a constant content of 50% clay. All bodies were made up under uniform conditions and fired to their proper maturing temperatures which varied from cones 8 to 20. Moduli of rupture for correctly fired bars varied from 5100 to 12,100 lbs. per square inch, those bodies high in mullite being the strongest. The coefficients of linear expansion between 30 and 844° C varied from 4.3×10^{-6} to 6.6×10^{-6}, those bodies high in mullite having the lower expansion. Thirty per cent or more calcined cyanite (50% or more total mullite as figured from chemical composition) must be present to obtain a marked effect on either of these properties. Triaxial diagrams show the position of various typical porcelain bodies and how they might be affected by additions of this material.

Introduction

The development of sillimanite or mullite, as it is now known to be,[4] during the firing process has long been noted in porcelain bodies. It is according to Bleininger and Riddle[5]

> a natural component of all hard fired porcelain and if not present in the form of large crystals imparts to the body constancy of volume upon heating. It lowers the thermal expansion and increases the refractoriness and resistance to sudden heating and cooling.

The work of Bleininger and Riddle did a great deal to arouse interest in the introduction of this material in larger amounts than form in normal feldspar, flint, clay porcelain bodies. The spark plug industry has been the first to develop its use and today at least two of the leading manufacturers widely advertise that they introduce into their porcelain bodies, either from natural or artificial sources, materials which produce mullite during the firing process.

The three minerals: andalusite, sillimanite, and cyanite ($Al_2O_3 \cdot SiO_2$) are commonly spoken of and used as sources of mullite. Each dissociates at a definite temperature into mullite and a form of silica or a highly siliceous glass.[6] Peck[7] suggests that due to the particular

[1] Published by permission of the Director, Bureau of Standards. Received, November 4, 1926.

[2] Superintendent, Columbus Branch, Bureau of Standards.

[3] Junior Ceramic Engineer, Columbus Branch, Bureau of Standards.

[4] N. L. Bowen and J. W. Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, **7**, 238 (1924).

[5] A. V. Bleininger and F. H. Riddle, "Special Spark Plug Porcelains," *Jour. Amer. Ceram. Soc.*, **2**, 564 (1919).

[6] J. W. Greig, "Formation of Mullite from Cyanite, Andalusite, and Sillimanite," *Jour. Amer. Ceram. Soc.*, **8**, 465 (1925).

[7] A. B. Peck, "Changes in Constitution and Microstructure of Andalusite, Cyanite, and Sillimanite at High Temperatures and Their Significance in Industrial Practice," *Jour. Amer. Ceram. Soc.*, **8**, 407 (1925).

mullite crystal alinement, cyanite might be a more desirable porcelain ingredient than andalusite or sillimanite providing it is calcined above the dissociation temperature to eliminate the volume change.

Object of the Investigation

Mullite is supposed to impart desirable properties to a body but there are little data available which give actual values for these physical properties. It is therefore the purpose of this investigation to show some of the physical properties of porcelain bodies consisting of clay, flint, feldspar, and mullite introduced as dissociated cyanite.

Procedure

The triaxial method was used to lay out the bodies in this study as shown in Fig. 1. The clay content was held constant at 50% as this is an average content in most whiteware bodies. Due to the fact that bodies 16 to 21 inclusive contained no feldspar, the maturing temperature would be beyond the commercial range and these were not made up.

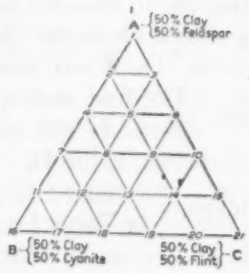

FIG. 1.—Body composition.

Navias[1] states from the results of X-ray determinations that the maximum amount of mullite, theoretically possible from the amount of Al_2O_3 present is developed in a clay, by firing it to cone 10 or above. Considering this to be true at cone 8 or higher for porcelain bodies, the theoretical amount of mullite which should be developed in these different bodies at cone 8 is shown in Fig. 2. The composition areas are marked for typical high tension, chemical and spark plug porcelain compositions as well as sanitary ware. The increased amount of mullite shown in early spark plug porcelain bodies and in chemical porcelain was usually introduced into the body as calcined clay. It is interesting to note that, figured on this same basis, the spark plug porcelain bodies of today often contain over 70% mullite.

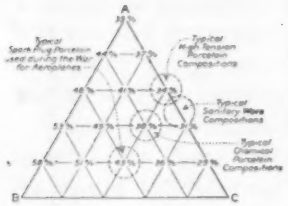

FIG. 2.—Theoretical percentages of mullite present.

From Fig. 2 the manufacturer of any type of porcelain should be able to locate his body with fair accuracy, and from subsequent triaxial diagrams showing the various physical properties should be

[1] L. Navias, "Quantitative Determination of the Development of Mullite in Fired Clays by an X-ray Method," *Jour. Amer. Ceram. Soc.*, **8** [5], 296 (1925).

able to judge its characteristics together with the advantages to be expected from the introduction of additional mullite by the use of cyanite or other materials.

Raw Materials

Cyanite The cyanite used was a high grade concentrate from a deposit near Pamplin, Virginia.[1] The chemical analysis is given in Table I.

This analysis indicates a mineral composition of 95% cyanite, 2% free quartz, and the remainder rutile and accessory minerals. In accordance with the findings of Greig[1] and Harrison the material was calcined to cone 18 for two hours to insure complete dissociation with its accompanying volume change. It was then crushed in a Braun pulverizer to 65-mesh and finer, run over a magnet to remove any iron introduced from the pulverizer and ground in a ball mill with flint pebbles. The screen analysis is shown in Table II.

Flint The flint used was the commercial grade of quartz sand potters flint. It was assumed to be 100% SiO_2. The screen analysis is shown in Table II.

Feldspar Potash feldspar was used. Its chemical analysis is shown in Table I and screen analysis in Table II.

It will be noted that the three nonplastic materials have approximately the same screen analysis.

TABLE I

CHEMICAL ANALYSES

	English china clay	Tennessee ball clay	Florida kaolin	Kentucky ball clay	Feldspar	Cyanite
Loss on ignition	13.4	12.8	13.5	12.4	0.5	0.4
SiO_2	45.8	45.6	48.8	49.3	67.3	37.3
Al_2O_3	39.0	38.7	36.8	32.6	19.4	59.9
Fe_2O_3	0.6	1.0	0.8	1.4		0.7
CaO		0.1	0.4	0.3	0.5	0.1
MgO		0.2				0.0
K_2O	1.2	0.3	0.4	1.0	11.7	0.0
Na_2O	0.3	0.9	0.1	0.3	0.8	0.3
TiO_2						1.2
P_2O_5						0.0

TABLE II

SCREEN ANALYSES

	Cyanite	Flint	Feldspar
Retained on 100-mesh	0.4	1.6	1.4
150	0.5	2.2	1.1
200	2.5	0.4	2.6
260	11.1	8.3	7.0
Through 260	85.6	87.6	87.9

[1] H. C. Harrison, "Cyanite Clay Refractories," *Jour. Amer. Ceram. Soc.*, 9 [5], 257 (1926).

Clays M.W.M. English China Clay: This is a washed secondary clay and is about average for its group in its physical properties. It has a porosity of 5% when fired to cone 14.

Tennessee Ball Clay, No. 7: This is a light colored fairly plastic ball clay vitrifying at cone 12.

Florida Plastic Kaolin: This is a washed clay of secondary origin. It is quite plastic for a kaolin and vitrifies at cone 14.

Kentucky Ball Clay, No. 4: This is a medium dark, rather plastic ball clay. It vitrifies at cone 12.

Method of Body Preparation

As previously noted the total clay content was kept constant at 50% throughout the investigation. To insure uniformity, a large batch was made up of the following composition:

20%	Kentucky ball clay	20%	Florida plastic kaolin
20%	Tennessee ball clay	40%	English china clay

It was then ground wet for one hour in an 18 x 30 inch ball mill, dried on muslin in plaster absorption bowls and dry ball milled. The bodies were weighed up in 1000 gram batches with 1500 cc of water and ground in gallon ball mills for one hour. The slip was screened through 150-mesh and the body dewatered on muslin in plaster absorption bowls to the proper working consistency.

The proper workability of the plastic mix was determined by a method devised in another investigation dealing with plastic clays. The method consisted of applying an 8000-gram weight to a one-inch cube of plastic clay. If the cube deformed to a height between $\frac{1}{2}$ and $\frac{5}{8}$ inch the workability was satisfactory. If greater than $\frac{5}{8}$ inch the clay was too stiff to be properly molded and if less than $\frac{1}{2}$ inch the clay was too sticky to be properly wedged. These limits were used in determining the workability of all bodies in this investigation.

Bars 1 x 1 x 7 inches were made in a brass mold and marked for linear shrinkage. These were dried and the drying shrinkages determined. As would be expected with uniform clay content, uniform working conditions and a uniform size of nonplastics, these shrinkages showed a variation of less than 1%.

Method of Firing

In order to get the approximate firing range, a preliminary draw trial firing was made in a gas-fired test kiln. Bars were drawn at two cone intervals from cones 8 to 18 and the correct firing temperature determined for each body. As all the pieces were vitrified or nearly so, the ordinary porosity measurements were not satisfactory. The pieces were therefore soaked over night in a concentrated alcoholic

solution of eosin dye. They were then broken open and the penetration of the dye noted. Figure 3 from left to right shows the effect of this dye on an underfired, correctly fired, and overfired piece. In the case of the underfired piece the dye has soaked in uniformly from the top. In the overfired piece it has followed the vesicles, while in the correctly fired specimen there is no penetration.

After the correct firing temperature had been determined for each body, firings were made to this temperature, two cones lower and two cones higher to obtain the firing range and also to make sure that correctly fired bars would be available if the draw trial conclusions as to temperature were not exactly correct.

Firings were made in a gas-fired test kiln to cones 8, 10, 12, 14, 16, 18, and 20. In each case the temperature was brought up to within three cones of that desired and held until the desired cone soaked down. The average time of firing was 24 hours and the cooling time 16 hours. The results as determined by the eosin method are shown in Table III.

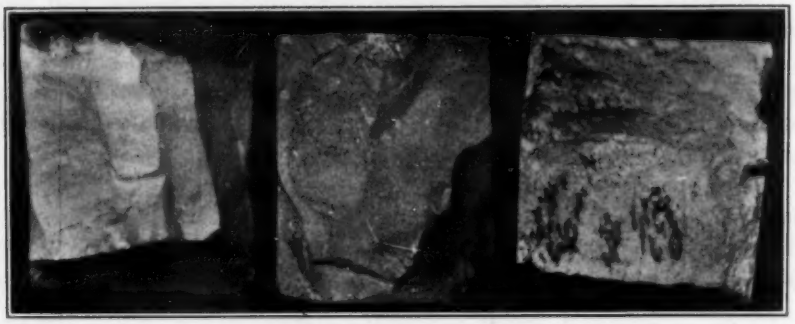

FIG. 3.—Results of eosin porosity test.

TABLE III

Cone fired to		8	10	12	14	16	18	20
Body	1	OK	OK	OF				
	2	OK	OK	OF				
	3	OK	OK	OF				
	4		UF	OF	OK			
	5		OK	OF	OF			
	6		OK	OF	OF			
	7				OK	OK	OK	
	8			OK	OK	OF		
	9*			OK	OF	OK		
	10			OK	OF	OF		
	11					OK	OK	OK
	12					OK	OK	OF
	13			OK	OK	OF		
	14			UF	OK	OF		
	15			UF	OK	OF		

OK Properly fired
OF Over fired
UF Under fired
* Cone 12 very slightly underfired
Cone 16 slightly overfired

Figure 4 shows graphically the effect of the various ingredients on the firing range. Where more than one cone is given the one underlined represents the temperature at which best results were obtained. The discrepancy in the case of bodies 4 and 9 is probably due to the position in the kiln although every effort was made to have uniform firing conditions.

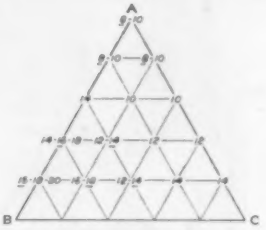

FIG. 4.—Correct firing temperature.

Results

Firing Shrinkage The firing shrinkage in terms of dry length for each body fired at the correct temperature is given in Table IV.

TABLE IV

Body	Cone	Firing Shrinkage Per cent	Body	Cone	Firing Shrinkage Per cent
1	8	9.98	9	12	10.61
2	8	11.0	10	12	11.02
3	8	10.62	11	16	8.86
4	14	10.85	12	18	9.66
5	10	10.75	13	14	10.28
6	10	10.52	14	14	10.40
7	16	9.61	15	14	9.32
8	14	10.78			

Modulus of Rupture The cross-breaking strength was determined in a modified Riehle Tension machine on a 5-inch span. The stirrup of the machine is shown in Fig. 5. The results were figured in moduli of rupture according to the formula:

$$M = \frac{3PX}{2\ bd^2}$$

where M = modulus of rupture in lbs. per sq. in.
P = breaking load in pounds
X = span in inches
b = width of test piece in inches
d = depth of test piece in inches

The results for an average of three bars fired at each temperature are given in Table V. The results for the correctly fired specimens are shown in Fig. 6.

Coefficient of Linear Expansion The coefficient of linear expansion was determined on a properly fired specimen 1 x 1 x 6 inches in an apparatus built by A. E. MacGee[1] and which will later be described by him. Check runs were made in each case to within $\pm 3\%$ at the higher temperatures. The results from 30

[1] Associate Ceramic Engineer, Columbus Branch, Bureau of Standards.

to t°C are given in Table VI. The coefficients from 30 to 844°C are also shown graphically in Fig. 7.

TABLE V
Modulus of Rupture (lb/in²) of Pieces
Cone Fired to

Body no.	8	10	12	14	16	18	20
1	8700	6400	3500	—	—	—	—
2	8400	6600	2000	—	—	—	—
3	7300	7100	2600	—	—	—	—
4		6000	3700	8100	—	—	—
5		7300	3000	4200	—	—	—
6		7700	2400	4100	—	—	—
7				6300	7800	6900	—
8			4300	9200	4300		
9			7700	3600	7000		
10			9200	2600	4500		
11					12100	9900	10300
12					5400	10100	7300
13			5300	9000	3700		
14			3400	7400	3500		
15			3600	5100	2700		

TABLE VI
COEFFICIENT OF LINEAR EXPANSION FROM 30°C TO t°C

t°	1	2	3	4	5	6	7	8
114	3.5	4.7	5.0	2.7	2.8	3.3	2.8	3.3
235	4.8	4.9	5.5	3.2	4.2	5.6	3.5	3.2
357	5.3	5.1	5.1	3.4	4.4	6.0	3.5	3.4
483	6.0	5.4	5.8	3.9	5.0	6.4	3.7	4.0
602	5.9	5.8	6.2	4.5	5.6	6.9	3.8	4.7
724	6.2	5.6	6.1	4.7	5.7	6.7	3.8	4.9
844	5.9	5.9	6.3	5.4	5.8	6.6	4.4	5.1

t°	9	10	11	12	13	14	15
114	4.1	3.1	2.2	1.7	2.7	2.2	3.6
235	4.0	4.8	3.4	2.0	3.7	3.5	4.1
357	4.4	4.6	3.5	2.7	4.2	3.9	4.6
483	4.6	5.8	3.9	3.5	4.8	4.2	5.2
602	5.5	6.5	3.9	3.8	4.9	4.8	6.0
724	5.2	6.2	4.2	4.0	4.9	4.8	6.0
844	5.5	6.3	4.6	4.3	5.2	4.8	6.4

NOTE: All figures for coefficients of expansion to be multiplied by 10^{-6}.

Discussion of Results

Linear Shrinkage There is nothing unusual in the firing shrinkage of the bodies. The shrinkage is lowest in the body containing the highest percentage of cyanite, although the one containing the highest percentage of flint is almost as low.

Modulus of Rupture The modulus of rupture tends to increase as the cyanite increases either at the expense of flint or feldspar. It will be noted, however, that 30% or more cyanite (or the total equivalent of 50% or more mullite) must be present before the effect is marked. It would seem that the value for body 15 was too low but this may be due to the large quantity of SiO_2 present and a strained effect produced in the body as this was cooled past the inversion temperatures. The value for body 7 also seems low

and it should be remembered that these results are an average on only three bars.

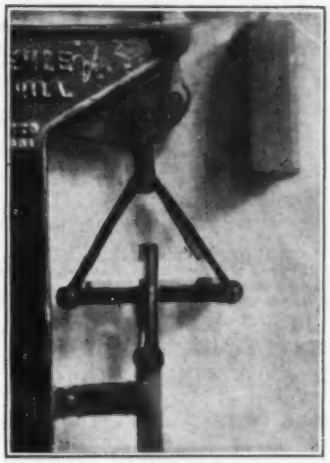

FIG. 5.—Cross-breaking apparatus.

Coefficient of Expansion The lowest coefficient of expansion is also found in the area of high cyanite or mullite and again 30% cyanite or 50% or more mullite is apparently necessary to improve the body markedly. The average coefficient of linear expansion of synthetic mullite as determined by the interferometer method and given by Shearer and Wyckoff[1] between the intervals 25 to 850°C is 4.6 x 10^{-6}. With the addition of 30% cyanite or 50% mullite the bodies in this series have reached this figure and it is probable that the presence of larger quantities would not greatly affect this physical property. The coefficients over the entire range as given in Fig. 7 are quite consistent. The slight discrepancies at the lower temperatures (Table VI) are probably due to the greater opportunity for the magnification of a slight error in reading.

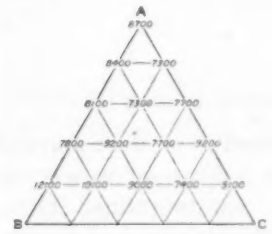

FIG. 6.—Moduli of rupture.

Other Properties The color of the series varied from good whites at the feldspar flint side to a gray at the cyanite corner. This is no doubt due to the iron-bearing accessory minerals in the cyanite. Unless highly purified this material could not be used where color of the body was an important item.

A microscopic examination of body No. 11 shows that the dissociated cyanite particles are imbedded in the ground mass which has developed mullite from the clay but there is little, if any, secondary development from the grains themselves. In other words, the effect of this material is not one of "seeding" or starting further development of mullite but rather the incorporation of an inert material of desirable physical properties in the ground mass. This is probably the reason why 30% or more must be added to get the desired results. Of course the difference in glass formed and the

[1] W. L. Shearer and W. R. Wyckoff, "Thermal Expansion of Whiteware Materials and Bodies over a Wide Temperature Range", *The Ceramist*, p. 349, March, 1926.

higher temperatures of firing must be taken into account. The fact that the calcined cyanite contained about 13% SiO_2 or highly siliceous glass seems to have little effect as it is held in place by the capillary attraction of the mullite needles and does not seem to be available to the feldspar glass formed as the body is fired.

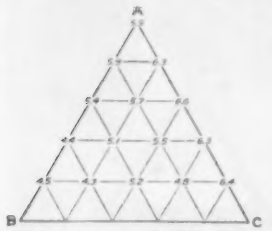

FIG. 7.—Coefficients of linear expansion ($\times 10^{-6}$) from 30 to 844°C.

Those bodies high in cyanite had a long firing range. This is probably due to the fact that the inert mullite particles were not to any appreciable degree taken into solution by the glass formed. Those bodies high in flint however showed a short firing range which corresponds with the results obtained by Potts and Knollman.

Conclusions

Mullite introduced as calcined cyanite, ground to a proper fineness and introduced in feldspar, flint clay porcelain bodies in amounts over 30% has the following tendencies on the physical properties of the bodies:

1. Increase in modulus of rupture
2. Decrease in coefficient of expansion
3. Increase in firing temperature required
4. Increase in firing range
5. Color gradation from white to gray due to the iron bearing accessory minerals

Thirty per cent or more of the material is required to produce marked changes in the body due to the fact that there is little or no seeding effect, *i.e.*, secondary mullite growth, from the cyanite grains. These apparently act merely as inert particles with desirable physical properties.

Acknowledgment

The authors wish to express their appreciation to G. A. Bole, Superintendent of Ceramic Experiment Station, Bureau of Mines, under whose direction a portion of the work was done, F. P. Hall who made the microscopic examinations, and A. E. MacGee for his help in the determination of coefficients of expansion.

BUREAU OF STANDARDS
COLUMBUS, OHIO.

[1] Amos P. Potts and Harry F. Knollman, "The Relation between Composition and Density of Feldspathic Porcelains," *Trans. Amer. Ceram. Soc.*, **15**, 318 (1913).

CERAMIC ABSTRACTS

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[1]The abbreviation (*C. A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

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Abrasives

The manufacture of grinding wheels. H. A. PLUSCH. *Ceramist*, **8** [7], 429–44 (1926).—P. describes the development and present method of manufacture of aluminous abrasives. The manufacturing processes and the materials used in making grinding wheels of aluminous abrasives are described in some detail. P. emphasizes the fact that the control of composition and treatment of grinding wheels is probably closer in its limits than on any other ceramic products manufactured at the present time. The grinding wheels must be duplicated on repeat orders so that they will give consistent and uniform performance. The finishing and testing departments are described. P. also describes the manufacture of SiC abrasives and grinding wheels. A table usually used for the designation of grades is given. A.E.R.W.

Grinding wheels for face grinding. ANON. *Continental Met. Chem. Eng.*, **1**, 40 (1926).—The degree of hardness of the grinding wheels required depends upon the mechanical properties of the worked materials, upon the width of the worked pieces, upon the speed of revolution of the wheels, and upon the condition of the grinding machine and the skill of the operator. Hard grinding material must be used for soft pieces, while soft grinding material is best for hard piece work. The wider the uninterrupted surface of the work piece, and the higher the speed of revolution of the grinding

wheel as compared to the respective speed of the work piece, the softer should be the grinding material. If the grinding wheel spindle springs, or is out of true, or if the support of the work piece is insufficiently secure, comparatively hard grinding wheels should be used. The better the state of the grinding machines and the more skilled the operator, the softer may be the grinding material used and the more economical is the process. 1. Corundum of comparatively high tenacity and low degree of brittleness: working material of high tenacity and strength; wrought iron, forging steels, bronzes of high strength. 2. Corundum of comparatively low tenacity and a high degree of brittleness: working material of very high strength and tenacity; hardened steel, alloyed steels, tool steels. 3. Silicon carbide: working material of less tenacity and strength, but brittle: cast iron, brasses, bronzes, copper, rocks, leather, coal.

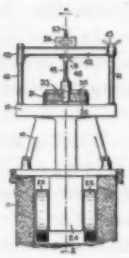
O.P.R.O.

German abrasive material industry. ANON. *Oil Color Trades Jour.*, **70**, 1466 (1926).—Grinding and polishing wheels and powders have greatly declined in the world market, due to over-production and a general decline in building industries. This decline is more keenly felt through Germany than other countries producing abrasives.

O.P.R.O.

PATENTS

Jolting apparatus and method of making articles of bonded grains. T. LARSSON AND C. J. HUDSON. U. S. 1,604,922, Oct. 26, 1926. The method of making an abrasive article of bonded granular material comprising the steps of intimately mixing abrasive grains with a ceramic bond and a fluid to form a moldable but non-fluid mass and thereafter jolting the mass to obtain a dense body of uniform composition throughout while confining it on all sides and preventing free movement of the top layer thereof so as to preclude the formation of laminations in the finished article.



Abrasive implement. EDWARD G. ACHESON. U. S. 1,607,715, Nov. 23, 1926. An abrasive implement comprising a compound of silicon, carbon, and oxygen, and substantially free from crystalline carbide of silicon.

Art

Modeled treatment of pottery. MARION L. FOSDICK. *Jour. Amer. Ceram. Soc.*, 9 [10], 697–700 (1926).—This paper is intended as one of a series on processes of decoration of pottery, and is a discussion of modeled treatment, where and how it is successful decoratively and from the point of view of practicality. The process of modeling with coils in low relief is given in detail. Vigorous pattern is used if the glazes are to be matt because of the thicker nature of the glaze which will obliterate subtlety in the modeling. Delicate pattern is used under thinner and more fluid glazes. Formulas are given for one series of vivid colors of a matt glaze and for a treatment of transparent, rather neutral glazes on a clay red-orange in color.

Personal experiences and national life as subject matter for design. MYRTLE M. FRENCH. *Jour. Amer. Ceram. Soc.*, 9 [11], 779–82 (1926).—Artists who lack ideas for design often resort to copying something made by a different people to express the life of a different age. As a result the design does not express America and is not in harmony with the natural expression of the American home. Many interesting symbolic designs have been worked out in class using personal experiences for the subject matter. Thus the designs have a new interest both to the artist and the public. If American industrial

art would encourage the artistic use of the wealth of material in our national life, the products produced would be given a soul which would make them alive.

Sino-Lowestoft. CHARLES O. CORNELIUS. *Bull. Met. Mus. Art*, 264–67, Nov., 1926.—Throughout the 18th century there was a great exportation of porcelain from China to the western world. Some of this ware was taken to Europe to be decorated there while some was decorated in China from European designs. Much of this was heraldic, masonic, or especially monogramed. In the American Wing there are a number of examples of this especially marked china, one of the most important being a dinner-service of 248 pieces bearing the coat of arms of Townley, and belonging to the Chase family of Annapolis. In the room from Petersburg, Va., there are specimens of George Washington's dinner-set and of one belonging to General Knox, Washington's Secretary of War. A covered cup with saucer is from a set of dishes owned by Martha Washington and bears her monogram. It is of the type decorated in Europe for the general American market. Some pieces have an adaptation of the coat of arms of the State of N. Y. Others have ships bearing the American flag in color. Three pieces of the dinner-set of William Pitt, Earl of Chatham, have recently been added to this group of porcelains. This china is very handsome and as excellent a type of the so-called Sino-Lowestoft as can be found. A.A.A.

Suggestions on ceramic art education. FREDERICK H. RHEAD. *Bull. Amer. Ceram. Soc.*, **5** [11], 410–16 (1926).—The ceramic art courses offered in England and on the Continent are discussed and detailed suggestions as to courses which should be included in any curricula intended to train artists with a working knowledge of ceramic technology and ceramic technologists with a working conception of art are offered. E.J.V.

What is art? R. GUY COWAN. *Bull. Amer. Ceram. Soc.*, **5** [11], 416–21 (1926).—Art in a general sort of way is the means by which one person can re-create in the minds of others the emotions he experiences. The differences of opinion as to what is and is not art or artistic are listed and discussed. The suggestion for young ceramic artists to study and make use of (1) line and form and (2) general color effect is offered. E.J.V.

Stained glass—is it a lost art? JOHN A. KNOWLES. *Nat. Glass Budget*, **42** [26], 16 (1926).—The belief that stained glass is a lost art is refuted by citing examples of modern stained glass which cannot be distinguished from ancient. The opinions of W. E. S. Turner and Noel Heaton are also quoted, refuting this belief. E. J. V.

Variety of colored and crystal glassware made by Paden City Co. ANON. *Nat. Glass Budget*, **42** [27], 12 (1926).—A description of various new lines of art glassware being produced by the Paden City Glass Mfg. Co., of Paden City, W. Va. E.J.V.

Some jade history. HENRY S. WASHINGTON. *Nat. Glass Budget*, **42** [29], 17 (1926); (reprinted from *Scien. Amer.*).—The physical, chemical, and optical properties of jadeite and nepherite are given and compared. Both minerals are known as jade but vary in their properties so they can be distinguished by simple tests. E.J.V.

The Washington Memorial Chapel gets last of stained glass windows. ANON. *Nat. Glass Budget*, **42** [26], 17 (1926).—A description of stained glass windows now all in place in the Valley Forge memorial. E.J.V.

BOOKS

Catalog of the George Eumorfopoulos Collection of Chinese, Korean, and Persian Pottery and Porcelain. Vol. III. From the T'ang to the Ming Dynasty—Chün, Ting, and Tz'u Chou wares. R. L. HOBSON. London: Ernest Benn, Ltd. Price 12 guineas.—725 numbered copies on Van Gelder mold-made paper, of which 660 are for

sale. Thirty numbered copies on Batchelor's Kelmscott hand-made paper, of which 25 are for sale. The letter-press is by the keeper of the Dept. of Ceramics and Ethnology at the British Museum. The 75 plates are all placed together at the end. A companion volume is promised of the Chinese frescoes recently acquired by E., and now in course of erection at the Museum. H.H.S.

Ancient Egyptian Materials. A. LUCAS. London: E. Arnold & Co., 1926. Price 7*s* 6*d*. H.H.S.

Cement, Lime, and Plaster

Franco-Belgian Association for Testing Materials. *Rev. Mat. Constr. Trav. Pub.*, **203**, 237–41 (1926).—(Meeting of July 5, 1926). FERET. *Studies on the duration of set and the re-mixing of concrete.* Mixtures of 500 kg. cement, 500 l. sand and 1 cu. m. of gravel were made. Mixture *A* was tempered with 9 % water, giving a plastic concrete mass, while mixture *B* with 7 % water was quite dry. Cubes 7 cm. on a side were made and after 48 hrs. they were removed from the molds, kept in humid air for 28 days, and tested for compression. The pure cement started to set after 6 hrs. and completed set in 10 hrs. The remixing was effected 1½, 5, and 8 hrs. after the first mixing. With concrete *A* the remixing was done without the addition of water, and the resulting strengths decreased as the length of time before mixing increased. With concrete B_1 molded immediately after mixing and B_2 molded after 1½ hrs., poor specimens were obtained. B_3 and B_4, molded after 5 and 8 hrs., were made with additions of water, both giving good products and high values, the last one being the strongest of all.

FLORENTIN. *A method of determining soluble silica in cements, mortars, and concretes and its application to the estimation of the cement content in mortars and cements.* F. criticizes several methods devised for determining the combined silica in cements, including a standard method of American origin. He suggests the following: 1 gm cement (or 4 g. mortar), very finely ground is dissolved in small portions in 50–60 cc cold HCl (d. 1.12 at 15°—1 vol. of water to 2 vols. of HCl at 21°B). It is important to keep the liquid cold by insertion in running water. The residue is then filtered on paper or on asbestos in a Gooch crucible. The silica in solution is then made insoluble by evaporation and weighed after ignition. The quantities of clay and sand dissolved by this procedure are very small, *i.e.*, clay 0.08, sand 0.10. Mortars were then made by weighing out 3 parts of sand and 1 part of cement. The soluble silica in each case was determined by the above method.

		Sol. silica in 1:3 mortars	
	Sol. silica in cement	Siliceous sand from Leucate	Calcareous sand from Seine
	%	%	%
Portland, 1st sample	21.15	5.30	—
" " 2nd "	20.70	—	5.50
Slag cement, 1st sample	23.85	5.74	—
" " 2nd "	24.40	—	5.60
Holderbank cement	18.15	4.25	4.53
Fused cement	8.65	2.05	2.25

These results correspond well to a 25% content of cement in the mortars.

RENGADE. *Influence of shape of test specimen on the absolute value and the relative precision of resistance to compression of mortars.* Comparative tests were made on Fig. 8 specimens (after breaking each into 2 parts in tension test) and cubes of 4 and 7 cm. One set of tests gave the following percentage deviations: tension 23.7 %, compression of half briquets (Fig. 8) 13.8 %, 7 cm. cubes 12 %, 4 cm. cubes 22.6 %. In another set the tension values gave a deviation of 22.5 % and compression a deviation of 13 %. The conclusion is reached that the Fig. 8 specimen which may be used for both tension and compression measurement is deserving of inclusion in present methods. L.N.

Patents process for making dolomitic lime plastic. F. C. MATHERS. *Cement Eng. News*, **29** [16], 47–48 (1926).—Description is given of a recently patented process for burning dolomitic limestones so that resulting lime gives a highly plastic hydrate. About .6% of common salt is added to limestone before burning. L.A.P.

Action of Na_2SO_4 and $MgSO_4$ on cement. ANON. *Cement Eng. News*, **29** [18], 69 (1926).—White cement made by heating powdered marble, alumina, and flint contained tricalcium aluminate, tricalcium silicate, and β-dicalcium silicate. Reactions of white cement with Na_2SO_4 and $MgSO_4$ differ from reactions of commercial Portland cement. Gypsum appears in the tests with commercial cement but not with the white cement. No sulpho-aluminate needles found in white cement as are found in commercial cement. The crystalline grains, centers of gelatinous particles, lasted for a much longer time in white cement. Differences thought to be due to ground gypsum in commercial cement and also to its higher percentage of MgO and Fe_2O_3. L.A.P.

The setting of litharge-glycerine cement. H. A. NEVILLE. *Jour. Phys. Chem.*, **30** [9], 1181–84 (1926).—Setting of litharge-glycerine cement, like the setting of plaster of Paris, is a 2-stage process: (*a*) adsorption of liquid phase by solid, accompanied by diminution in volume, and (*b*) exothermal chemical reaction between liquid so adsorbed and adsorbent. Rate of setting depends upon form of PbO used and upon dryness of glycerine. Water, stirring, and OH^- ions accelerate setting. H^+ ions inhibit or prevent setting. Water and $Pb_3(C_3H_4O_2)_2$ are reaction products, the latter being completely hydrolyzed by boiling water. L.A.P.

Tentative specifications for gypsum molding plaster. *A.S.T.M. Tent. Stand.*, 265–66 (1926); Ser. Designation, C 59–26 T.—Definition of gypsum molding plaster is given. Such properties as composition, time of setting, tensile strength, and fineness are described. Requirements as to sampling, methods of testing, packing and marking, and inspection and rejection are outlined. Criticisms invited. R.A.H.

Tentative specifications for gypsum pottery plaster. *A.S.T.M. Tent. Stand.* 267–68 (1926); Ser. Designation, C 60–26 T.—Definition of gypsum pottery plaster given. Such properties as composition, time of setting, tensile strength, and fineness are described. Requirements as to sampling, methods of testing, packing and marking, inspection and rejection are given. Criticisms invited. R.A.H.

Standard specifications and tests for Portland cement. *A.S.T.M. Tent. Stand.*, 1026 (1926); Ser. Designation, C 9–26.—Notification is made that a revision in the form of a separate tentative specification entitled "Specifications and tests for compressive strength of Portland cement mortars (C 9–16 T) is intended to become a part of the present standard specifications. R.A.H.

Standard definitions of terms relating to the gypsum industry. *A.S.T.M. Tent. Stand.*, 1030 (1926); Ser. Designation, C 11–26.—Revisions in the form of tentative definitions of terms entitled "Definitions of terms relating to the gypsum industry (C 11–26 T) are intended to become a part of the present standard definitions. R.A.H.

Moduli of rupture and elasticity of some gypsum mixes. ANON. Bur. Stand., *Tech. News Bull.*, No. 115, 7 (1926).—In "poured in place" construction, where calcined gypsum is used as the cementitious material, it is common practice to mix from 12 to 15% by weight of wood filler with the gypsum. A number of measurements have been made to determine the effect of the amount and type of filler on the moduli of rupture and elasticity of "first settle" and "second settle" gypsum. A table is given showing the results obtained. R.A.H.

Strengthening and indurating concrete with sulphur. W. H. KOBBÉ. *Eng. News-Rec.*, **96** [23], 940–42 (1926).—Tests extending over a number of years, and observations of some precast concrete in place have shown that concrete may be impregnated with molten sulphur with an increase in strength and decrease in absorption. The characteristics of sulphur are described, conditions of impregnation, effect on concrete, and reasons for strength due to sulphur impregnation. Water absorption is reduced to less than 2 or 3% in concrete so treated. R.A.H.

Rapid hardening and special cements. ANON. *Can. Eng.*, **51** [11], 297–98 (1926).—Aluminous cements, rapid setting Portland cement, and blast furnace slag cements are briefly described. Some data pertaining to tension and compression tests with aging as a factor are given on the former two. R.A.H.

Calcining of small limestone. W. M. MYERS. *Glass Ind.*, **7** [11], 275 (1926); (Partial reprint from *Bur. of Mines Ser.*, 2762).—The simplicity of calcining small limestone, in theory, is discussed. In actual practice many difficulties are presented, such as blocking the draft in any type of shaft kiln, development of a partial pressure of carbon dioxide which prevents further reaction unless continuously removed, etc. A new method of manufacture of lime by using a sintering machine for small limestone is described. E.J.V.

Cement in Canada. ANON. *Can. Min. Jour.*, **47**, 1076 (1926).—According to the final estimate of the Dominion Bureau of Statistics, shipments of cement from Canadian mills for 1925 totalled 8,116,597 barrels valued at $14,046,704. Cement is produced in Quebec, Ontario, Manitoba, Alberta, and British Columbia. The production of puzzuolan cement from blast furnace slag has been discontinued in Nova Scotia. Ontatio is the largest producer. Importations during the year amounted to 21,849 barrels averaging $2.89 per barrel. The 11 firms operating in the cement industry employ 105 salaried employees and 1821 wage earners. The cost of fuel and electricity was $2,848,954. H.H.S.

Ferrous and aluminous cements: considerations on hydraulic compounds. ERNEST MARTIN. *Non. sci.*, **16** [5], 97–101 (1926).—M. considers that the theory which attributes the hydraulic properties of Portland cements to tricalcium silicate and to tricalcium aluminate is entirely wrong, that the compounds of SiO_2 with CaO are much more complex and contain several Si atoms in the mol, that tricalcium aluminate does not exist in Portland cements, and that in the course of clinkering the Al_2O_3 of the Al silicates enters into highly complex reactions with formation of compounds containing Al_2O_3, SiO_2, and CaO. Absence of tricalcium aluminate in Portland cements follows from experiments reported at the last French Chemical Congress (as yet unpublished). Hydraulic properties are essentially an attribute of CaO, and to a much slighter extent of MgO. Hydraulic cements are the insoluble or almost insoluble inorganic CaO compounds which can be hydrated or hydrolyzed, and include certain silicates, the aluminates, certain ferrites and certain titanates; but similar salts of the same acids with other bases, *e.g.*, BaO or SrO, are quite devoid of hydraulic properties. Till recently it was admitted that in cement making Fe_2O_3 acted merely as a flux, the Ca ferrites having no hydraulic properties. M. has found that all fused Ca ferrites are devoid of hydraulic properties, irrespective of their CaO contents; but of the unfused ferrites $3(2Fe_2O_3 \cdot 5CaO)$, $2Fe_2O_3 \cdot 6CaO$, $2Fe_2O_3 \cdot 7CaO$) have hydraulic properties, while those with either higher or lower CaO contents are not hydraulic. The hydraulic ferrites are prepared by heating a mixture of theoretical proportions of Fe_2O_3 and CaO below the melting point; if the temperature is raised to or near the melting point the hydraulic properties are destroyed. The product, variously known as fused, electrical, or aluminous cement, which is prepared by fusion of bauxite in presence of CaO, owes its properties to certain

Ca aluminates. M. has found that hydraulic Ca aluminates could also be prepared without fusion, thus allowing for the manufacture of unfused and even unclinkered aluminous, ferrous, or alumino-ferrous cements at a cost much lower than that of ordinary fused cement, and approximately or slightly lower than that of Portland cements. Raw materials particularly suitable for the purpose are bauxite, waste sludges from Al_2O_3 plants, and cinders from pyrites furnaces. They are fired below the melting point of mixtures, generally about 1100–400°, so that they are discharged from the kiln in a pulverulent or slightly agglutinated condition. By avoiding fusion of the SiO_2 present as an impurity, inactive Ca silicates are produced, which are not attacked by natural waters; whereas if the SiO_2 were fused it might give compounds which would facilitate corrosion by gypsum-bearing waters. Unfused cements do not expand after setting, as sometimes do both fused and Portland cements. By judicious proportioning of the ingredients, the properties of the finished product, particularly as regards time of setting, strength and resistance to sulphate-bearing waters, can be modified at will. M. disagrees with Candlot's opinion that destruction of Portland cement concretes is due to the formation of a Ca thioaluminate, for the 2-fold reason that Portland cements contain no Ca aluminate and that both fused and unfused aluminous cements, which contain Ca aluminate and give thioaluminates with $CaSO_4$ are not destroyed by sulphate-bearing waters. Mortar made from unfused aluminous (free from, or low in Fe_2O_3) cement and bauxite is highly refractory and does not disintegrate at the highest temperature encountered in industrial furnaces. (*C. A.*)

PATENTS

Quick-setting lime products. M. E. Holmes and G. J. Fink. U. S. 1,604,574, Oct. 26, 1926. A non-argillaceous plastic material having quick initial setting properties comprising substantially commercially pure hydrated lime, prepared by slaking with water, and a soluble sulphate of a metal, the atomic weight of the metal being between 52 and 59, said sulphate reacting principally upon the hydrated lime to produce the quick setting properties.

Production of quick-setting lime products by the addition of carbonates. M. E. Holmes and G. J. Fink. U. S. 1,604,575, Oct. 26, 1926. A cementitious material having quick initial setting properties comprising hydrated lime and a metal carbonate which readily hydrolyzes.

Production by carbonation and the addition of sulphates of plastic materials having an initial quick set. F. C. Mathers and R. L. Hardy. U. S. 1,604,576, Oct. 26, 1926. A plastic material having quick initial setting properties consisting of the reaction products of carbonated hydrated lime and a soluble compound having a sulphate radical.

Quick-setting lime and process of making same. J. W. Stockett, Jr. U. S. 1,604,577, Oct. 26, 1926. The process of making a lime product which consists in mixing quicklime with substantially completely hydrated lime in the presence of water, pouring said mixture into a mold substantially immediately after mixing, and molding without agitation whereby the reaction between the mix-constituents occurs.

Enamels

Gas-fired enameling furnaces: comparative results of intermittent, semimuffle, and full muffle types. H. H. Clark. *Bull. Amer. Ceram. Soc.*, 5 [11], 423–24 (1926).—Data on 3 types of gas-fired enameling furnaces are presented and show that the semimuffle is the best, being lowest in first cost, operating expense, and in maintenance, per unit of production. E.J.V.

Soundness in steel tubes. ANON. *Engineering*, **122,** 19(1926).—Corrosion and pitting are associated with segregates. Segregates include sulphides, but seldom consist mainly of them. The low S found in Swedish steel does not make it reliable against segregation and the troubles that arise from it. Segregation occurs in the ingot, and no matter what physical or mechanical treatment it or its products may receive, they carry the segregates with them throughout their life until they are remelted. Accordingly failure may be avoided most easily if an examination by sulphur printing is made on the original ingot. H.H.S.

Sheffield and metallurgical development. R. HADFIELD. *Engineering*, **122,** 43–44, 50(1926).—An address delivered at the opening of the new Eng. and Met. Labs. at Sheffield Univ., July 2, 1926. Owing to Sorby, Sheffield was the birthplace of the science of metallography; H's. manganese steel made it the home of modern steel alloys; and the American, Holley, owed to Sheffield his training in the Bessemer process. Other important advances of the past 50 years have been the perfecting of chemical analysis; the precise measurement of high temps. and of the effects of thermal treatment on the molecular structure of iron and steel; and the improvement and general adoption of electric steel-melting furnaces. H.H.S.

Interpretation of macrostructure of cast metals. R. GENDERS. *Engineering*, **122,** 88–90(1926).—When a mold is filled with liquid metal, solid crystals first form in contact with the mold and grow inward at right angles approximately to the surface. Because each crystal is confined laterally by similar crystals, their shape becomes columnar; these are known as chill crystals. Should the casting temperature be sufficiently low, or the rate of solidification slow enough, isolated centers of crystallization form in the interior and grow radially to form, roughly, equiaxed ("free") crystals. The relative propns. of columnar and "free" crystals give definite indication of the initial temperature of the metal and of the rate of cooling, which latter is determined by the mold. It is generally recognized that the most desirable macrostructure is one consisting entirely of "free" crystals, and accordingly the lowest possible casting temperature is used, especially for some alloy steels which are particularly apt to crack along diagonal planes during cooling. In very large castings, where cooling is slow, a high casting temperature is permissible, and advantageous in eliminating suspended inclusions of non-metallic matter. Defects in iron castings which are connected with macrostructure consist of irregular-shaped interdendritic cavities due to shrinkage, and planes of weakness due to solidification of low melting point impurities between the dendrites; these also occur along diagonal junctions which are formed by the convergence of chill crystals growing from adjacent faces of the mold, and, at the bottom of the casting, on pyramidal planes. Blowholes due to the liberation of gas on freezing are distributed throughout the casting, but one type of blowhole, found near the surface, is related to macrostructure, since it is produced in top-poured ingots by interaction of carbon in the iron with the oxide formed on metal splashed against the wall. G. then discusses nonferrous alloys, and states that indications to be gained from iron castings when applied to brass etc. would only be true to a limited extent, *e.g.*, it is not always possible to reconstruct from the macrostructure the conditions of castings. H.H.S.

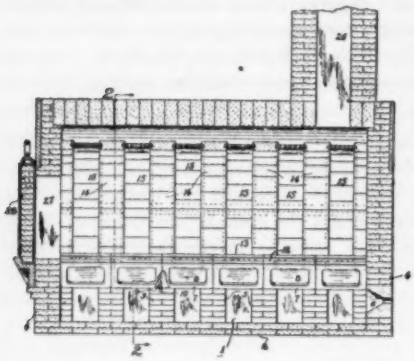
BOOKS

Metallography of Steel and Cast Iron. W. E. WOODWARD. London: Crosby, Lockwood & Son, 1926. Price 15*s*. H.H.S.

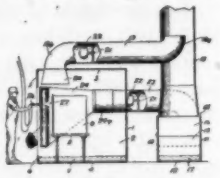
Metallography and Heat Treatment of Iron and Steel. A. SAUVEUR. Third ed. Cambridge, Mass.: Univ. Press, 1926. H.H.S.

PATENTS

Muffle furnace. L. W. MANION. U. S. 1,607,681, Nov. 23, 1926. In a furnace of the character described, a muffle provided with a bottom wall of substantially uniform thickness throughout its area having alternate similar ridges and depressions, the ridges being arranged to support firing racks and the depressions being arranged to receive charging forks.



Spraying cabinet. J. F. CURREN. U. S. 1,608,082, Nov. 23, 1926. In combination, a cabinet having an open front side, an enclosed reclaiming chamber located back of the cabinet, a vertical stack extending upwardly from the upper side of the chamber and communicating therewith, 2 pipes connected with the upper side of the chamber, one at each side of the stack and extending forward through the back of the cabinet, a nozzle connected to the front end of each pipe having an open front end, the ends of the nozzles being turned toward each other, means within the pipes for causing air to be drawn rearwardly therethrough, and a liquid container in the lower portion of the cabinet having an area substantially equal to the area of the bottom of the cabinet.



Leadless enamels. C. TOTOT-GIBARU. Addition 30,444, Jan. 5, 1925, to French Pat. 597,146; Brit. Pat. 323 (1926).—The metal is first coated with a powdered mixture containing 22.63% SiO_2, 3.76% Al_2O_3, 3.5% CaO, 23.44% ZnO, 16.6% Na_2O, 2.63% K_2O, 12.5% Sb_2O_3, 13.72% B_2O_3, and 2.02% F, then with a similar mixture containing 15.06% SiO_2, 1.08% Al_2O_3, 12.65% CaO, 18.48% Na_2O, 30.12% ZnO, 21.15% B_2O_3, and 2.43% F. (*Brit. C. A.*)

Glass

Some observations of surface deposits formed in glass furnace regenerators. HERBERT INSLEY. *Jour. Amer. Ceram. Soc.*, 9 [10], 635–38 (1926).—Two high alumina refractory brick which had been used in glass furnace regenerators were examined with the petrographic microscope. The deposits formed on the surface of the brick through reaction with the dusts and gases of the furnace atmosphere were found to be composed principally of nephelite, carnegieite, and corundum. Nephelite and carnegieite probably can form only in those parts of glass furnaces where the temperature is considerably lower than that required to melt the glass, but corundum may be formed at melting temperatures.

Wearing away of tank blocks. DONALD W. ROSS. *Jour. Amer. Ceram. Soc.*, 9 [10], 641–53 (1926).—A statement concerning the manner of the wearing away of tank blocks, factors affecting such wear, and detailed studies of surfaces of used tank blocks.

The mullite content of some American tank blocks. FRED S. THOMPSON AND HOWARD I. VORMELKER. *Jour. Amer. Ceram. Soc.*, 9 [10], 639–40 (1926).—Samples of the various glass tank blocks manufactured in the United States were analyzed for mullite by the hydrofluoric-acid method.

Glass wool as insulator for refrigeration purposes. H. C. BATES. *Jour. Amer. Ceram. Soc.*, 9 [10], 690–92 (1926).—A new method has been used to measure the thermal

conductivities of insulating materials which consists of the observation of the rate of melting of ice in a vessel insulated with the material under investigation. This is done by noting the change of volume of the mixture of ice and water by means of a graduated glass tube connected to the vessel. Results are given for glass wool of various densities, powdered cork, magnesia asbestos composition, slag wool, Sil-O-Cel powder, cotton waste, and sheep's wool. It is also shown that glass wool that can be kept dry is a very superior insulating material.

Electromotor properties of glasses. K. HOROVITZ. *Akad. Wiss. Wien. Ber.*, **134** [7–8], 354 (1925); *Sci. Abs.*, **29**, 523 (1926).—Pb glasses have the same relations of a H-electrode for all concentrations of hydrogen. With all these glasses additions of metal cations altered the e.m.f. The conductivity has no direct relation with the H-electrode function. With K glasses the use of KOH instead of NaOH in the acid-alkali cell lowers the e.m.f.; the contrary with Na glasses. D.E.S.

Interchange of ions in glasses. K. HOROVITZ AND J. ZIMMERMANN. *Akad. Wiss. Wien. Ber.*, **134** [7–8], 355–83 (1925); *Sci. Abs.*, **29**, 523 (1926).—Hard glass takes up Ag-ions to such an extent that it can come to act as a reversible Ag-electrode. For each kind of glass and each kind of ion there is particular concentration in the solution which brings about this reversible electrode effect. Thermodynamic considerations require that on current passing from a $AgNO_3$ solution into glass Ag should be taken up by the glass; this has been confirmed in Toronto by M. J. Mulligan. D.E.S.

Artificial double refraction caused by pressure on a glass cylinder. H. RIETH. *Ann. d. Phys.*, **79**, 145–76 (1926); *Sci. Abs.*, **29**, 399 (1926).—In the first case considered the cylinder is mounted with its axis horizontal and subjected to a radial pressure over its lower half. This is balanced by a vertical downward pressure applied at the upper end of the vertical diameter of the face. The distribution of tension in the cylinder is calculated mathematically and compared with that found experimentally from the double refraction in the glass at various points. The agreement is fairly satisfactory. In less detail the 2 following cases are considered: (*a*) pressures applied at the ends of the same diameter; (*b*) pressure applied at points 120° apart. D.E.S.

Thermal expansion of Jena glass. F. P. G. A. J. VAN AGT AND H. K. ONNES. *K. Akad. Amsterdam, Proc.*, **28** [7], 667–73 (1925); *Sci. Abs.*, **29**, 248 (1926).—The thermal expansion of Jena glass 16^{III} at low temperatures was measured by observations upon the position of Pt points sealed into both the bottom and top of the inner and outer walls of a vacuum vessel. The outer wall was maintained at room temperature while the inner was cooled to the boiling point of ethylene, oxygen, and hydrogen respectively. The results show that at low temperatures a_t does not vary linearly with the absolute temperature but shows the character of the specific heat. It is probable that for most substances the form of the expansion coefficient curve is the same as for glass and is nearer to that predicted by the Lindemann theory than to that predicted by Debye. D.E.S.

Annealing of optical glass. A. A. LEBEDEFF. *Rev. d'Optique*, **5**, 1–30 (1926); *Sci. Abs.*, **29**, 401 (1926).—An important factor in annealing optical glass is the discontinuous change in refractive index at a critical temperature associated with polymorphic transformations in the glass. This may leave a residual variation in the refractive index amounting to several units in the 3rd decimal place. The polymorphic transformation takes place in the same way as that in solid solutions. At any temperature in the critical region there is a definite complete equilibrium and a relatively simple method of measuring the refractive index of the glass in this state given. The results show that the refractive index is then a linear function of the temperature. A method for transforming glass to the modification stable at lower temperatures is given and the part played by the presence of internal strain and lack of homogeneity is discussed. D.E.S.

Testing prisms and glass plates. A. AUBERTIN. *Rev. d'Optique*, **5**, 161–82 (1926); *Sci. Abs.*, **29**, 707 (1926).—Gives geometrical and interference methods for exact measurement of the right angle of a totally reflecting prism and the angle between the faces of a plate of glass. By the use of very fine pencils of light, defects in the pieces studied can be localized. D. E. S.

Effective wave-length of pyrometer glasses. F. HENNING. *Zeit. Instrumentenk.*, **45**, 530–38 (1925); *Sci. Abs.*, **29**, 252 (1926). D.E.S.

Penetration of glass. LYDIA INGE AND A. WALTHER. *Zeit. Phys.*, **37** [4–5], 292–303 (1926); *Sci. Abs.*, **29**, 661 (1926).—I. and W. have previously shown that with rock salt at high temperature the electrical penetration can be accounted for by the theory of heat with very great accuracy. In the present paper the penetration tension for glass at different temperatures is investigated and it is found that the whole range of temperatures can be placed into 2 groups: (1) corresponds to the higher temperatures in which the penetration tension depends on the temperature; (2) corresponds to low temperatures where no such dependence is indicated. It is shown that at the higher temperatures the most important demands of the theory of heat on the corresponding penetration are fulfilled. At the lower temperatures the penetration cannot be explained by the theory of heat, but here another mechanism is responsible in which the degree of inhomogeneity of the elect field plays a very important part. D.E.S.

Adsorption of gases by glass and silver powders. F. DURAU. *Zeit. Phys.*, **37** [6], 419–57 (1926); *Sci. Abs.*, **29**, 742 (1926).—Measurements of the number of gas-layers deposited. Carbon dioxide on glass presents pure adsorption. D.E.S.

Thermal history and optical constants of glasses. F. ECKERT. *Zeit. tech. Phys.*, **7** [6], 282–87 (1926); *Sci. Abs.*, **29**, 707 (1926).—The N/D of a glass depends upon the time the glass had remained in the plastic condition. The optical constants depend upon the recent thermal history. The homogeneity of an optical glass melt measured; rules for the reproductability of 3 melts under similar conditions. D.E.S.

Signal green glass. E. ZSCHIMMER, C. M. GRISAR, AND H. MEESS. *Zeits. tech. Phys.*, **7** [6], 290–300 (1926); *Sci. Abs.*, **29**, 707 (1926).—Glasses of various compositions containing 4.5% of CuO; absorptions of blue and red; guides to an ideal signal green glass. D.E.S.

Glass industry in Belgium and Czechoslovakia. ANON. *Amer. Glass Rev.*, **46** [5], 15–17 (1926).—A résumé of latest developments shows radical changes to machinery in Belgian window glass manufacture and fair export trade while in Czechoslovakia there is a continued depression which has resulted in a curtailment of operations to some extent. E.J.V.

Improved factory for Fostoria quality ware. J. M. HAMMER. *Amer. Glass Rev.*, **46** [6], 15 (1926).—A description of the extensive changes to match automatic machine plants with new equipment and modernizing of processes in the Moundsville, W. Va., plant of the Fostoria Glass Co., where quality and not quantity is paramount. E.J.V.

Chemical treatment of glass. HOWARD B. BISHOP. *Amer. Glass Rev.*, **46** [7], 17 (1926).—The 2 methods of affecting the surface of glass, mechanical and chemical are discussed. The chemicals used and methods of obtaining different results with them are listed. E.J.V.

One machine for complete pressed glassware line. ANON. *Amer. Glass Rev.*, **46** [7], 19 (1926).—An automatic glassware pressing machine capable of making an entire small glass factory line is described and an illustration of the many articles which can be produced on this PCF machine made by the Wm. J. Miller, Inc., of Swissvale, Pa., is shown. E.J.V.

To make imitation polished wire glass. ANON. *Amer. Glass Rev.*, **46** [7], 26 (1926); *Nat. Glass Budget*, **42** [29], 5 (1926).—The new wire glass soon to be produced com-

mercially by the Paul Wissmach Glass Co. of Paden City, W. Va., is called "imitation polished" because, while not polished, it has more translucency than ordinary unpolished wire glass. Methods of manufacture of it are described. E.J.V.

Strain and the hot water test for bottles. D. J. McSwiney. *Glass Ind.*, **7** [11], 261–63(1926).—The hot water test used as a criterion of the degree to which ware has been annealed is discussed. This is based on an erroneous assumption, proof of which is found in a comparison of results of tests on annealed and unannealed ware. No definite conclusions can be drawn due to the erratic nature of the results obtained, but it is very evident that the presence of strain does not necessarily lower the resistance of the ware to heat shock but may increase the resistance. The factors influencing the resistance of ware to heat shock are: (1) composition of the glass, (2) the size and shape of the ware and the thickness of the walls and bottom, (3) the uniformity of distribution of the glass in the ware, (4) the presence or absence of checks, cords, blisters, variations in glass composition or other defects, (5) the character of the hot liquid and the way it is filled into the ware, (6) the temperature differential between the glass and the hot liquid, (7) the character of the medium in contact with the side of the glass opposite to that with which the hot liquid comes in contact and the rate at which the bottles and the hot liquid are brought into contact. E.J.V.

The glass-making methods and batches of twenty-five hundred years ago. R. Campbell Thompson. *Glass Ind.*, **7** [11], 264–67(1926).—A partial translation of ancient tablets which gives in actual details the methods in vogue in Assyria in the 7th century, B.C. These give not only the Assyrian names for the different kinds of glass and glazes but the actual formulas for the components and proportions for their manufacture. E.J.V.

Analysis of zirconium glasses. Anon. *Glass Ind.*, **7** [11], 269–70(1926).—The occurrence of zirconium in nature and its use in glass manufacture are discussed. Methods of analysis of glass containing zirconium are outlined. E.J.V.

On the sensitiveness of optical glass to spots. Herman Heinrichs and Walter Tepohl. *Glastech. Ber.*, **3** [6], 213–22(1926).—The test of stability of glasses determined by their resistance to water in the liquid or vapor state, and the characterization of stability of many optical glasses will not suffice. It is known that many glasses which pass the water test are apt to be spotted and thus become worthless for optical glass. Several methods of testing the stability of glasses by treating them with various different solutions are described in considerable detail and discussed. Classification of glasses according to the reaction to the treatments mentioned is explained. E.J.V.

Glass and machinery—ancient and modern. E. J. Barry. *Nat. Glass Budget*, **42** [25], 19–20(1926).—An historical account of the development of glass, glass plants, and glass-working machinery, with special stress on the American glass industry and developments therein. E.J.V.

Whitall Tatum Company has modern plants; annual capacity over million gross of bottles. Anon. *Nat. Glass Budget*, **42** [27], 3(1926).—A description of the equipment and layout of the modern plants at Millville, N. J. The decrease in operating force with increase in mechanical equipment is commented upon. No decrease in production resulted in reducing the force over 50%. E.J.V.

Shanghai glass factories. Anon. *Nat. Glass Budget*, **42** [27], 12(1926); (reprinted from *Far East. Rev.*).—Chinese glass factories in Shanghai are listed and information as to raw materials used; working forces and capitalization is given. E.J.V.

Cobalt-blue glass with cerium oxide excludes actinic rays of light. A. N. Finn. *Nat. Glass Budget*, **42** [27], 17(1926); see also *Ceram. Abs.*, **5** [9], 269(1926). E.J.V.

Modern vs. ancient glass. ANON. *Nat. Glass Budget*, **42** [27], 18 (1926); (reprinted from *House Beautiful*).—A discussion of Steuben glass made by the Corning Glass Co., comparing it with ancient glass. E.J.V.

The Paul Wissmach Glass Co., Inc., uses modern methods in making wire and other glass. ANON. *Nat. Glass Budget*, **42** [29], 3 (1926).—A description of the plant and methods used in producing the various kinds of glass placed on the market by this Company. E.J.V.

Corning's new glass. ANON. *Nat. Glass Budget*, **42** [29], 9 (1926); (reprinted from *Time*).—A note regarding a new Corning glass which transmits 86% of sunlight's ultra-violet content. E.J.V.

Mirror twenty-five feet in diameter proposed for massive telescope. W. J. LUYTEN. *Nat. Glass Budget*, **42** [29], 24 (1926); (reprinted from *N. Y. Times*).—A description of a proposed telescope to weigh 1,600 tons and requiring a mirror 25-ft. in diameter capable of gathering 2 million times as much light as the human eye. The development of the reflecting telescope is traced. E.J.V.

History of glass making. Stiegel Glass. JOSEPH F. HEFFRON *Glass Container*, **5** [11], 11, 13, 26, 32, 34, (1926).—Good escription on this famous early American glass. W.M.C.

History of glass making: early glass works in New York and New England States. J. F. HEFFRON. *Glass Container*, **5** [11], 9, 10, 11, 24, 26, 30 (1926).—Covers Saratoga Glass Works, New Hampshire plants, Pitkin Glass, Sandwich Glass. W.M.C.

Maintenance of detergent solutions used in bottle washing. M. E. PARKER. *Glass Container*, **5** [11], 7, 8, 38, 42 (1926).—Describes methods for checking strength of solutions and advantages of different soda compounds used for this purpose. W.M.C.

Detection of cadmium and arsenic in glass. W. GEILMANN. *Glastech. Ber.*, **4**, 92–97 (1926).—The method, based on that of Biewand, consists in placing a mixture of powdered glass and anhydrous sodium oxalate at the closed end of a glass tube, which is then drawn into a capillary above the powder. By suitably heating the mixture a metallic sublimate is deposited in the cold capillary. It is possible to detect 0.0025% of cadmium in 0.1 g. of glass or by microchemical means 0.1 g. in 2 mg. The same procedure may be used for testing for arsenic in glass, whereby 0.0025% may be detected in 0.1 g. (*Brit. C. A.*)

Temperature-time curves of the visible devitrification of plate glass. E. ZSCHIMMER AND A. DIETZEL. *Zeit. tech. Phys.*, **7**, 278–82 (1926); *Chem. Zentr.*, **2**, 1320 (1926).—A devitrification apparatus with a crucible thermoelement is described which permits test-pieces of glass of 0.05 g. weight to be heated rapidly to the devitrification temperature and cooled with simultaneous exact temperature and time measurements. Phenomena so observed in the devitrification of Waldhof plate glass are described. Maximum lengths of the crystals were measured in thin sections of the devitrified samples treated over various temperatures and times. The rate of crystallization was fixed, and the curve showing its relationship to the temperature plotted; the maximum lay at 1005°, at which temperature crystals 20μ in length formed in one minute. Temperature and time curves for crystal lengths of 10, 50, and 100μ are discussed. In the above-named samples the crystals obtained at 1000° were identified by X-ray methods as tridymite and wollastonite. (*Brit. C. A.*)

PATENTS

Method of manufacturing decorative glassware. P. W. JENKINS. U. S. 1,604,557, Oct. 26, 1926. The method of manufacturing an incrusted glass article, which comprises blowing a mass of plastic glass within a mold having an area of its surface provided with a relief design, and by such blowing simultaneously shaping the article and forming

a shallow coating-retaining relief design of sharp outline on an area of the outer surface of the article, and subsequently forming an adherent coating on relief area of the article.

Actinism proof reënforced glass. J. H. SHERTS. U. S. 1,604,761, Oct. 26, 1926. As an article of manufacture, a reënforced glass structure comprising a sheet of glass, a layer of material which tends to change color when exposed to actinic rays of light and a ray-filter layer.

Method and apparatus for flattening sheet glass. J. HARTZELL. U. S. 1,604,823, Oct. 26, 1926. Glass flattening apparatus, including a flattening oven, a flattening wheel therein having flattening surfaces adapted to be moved to successive position by rotation of the wheel, means for supplying heat above one of such positions, means for passing cooling fluid below this position and a succeeding position, a partition between such positions, and means for withdrawing hot gases from above the succeeding position.

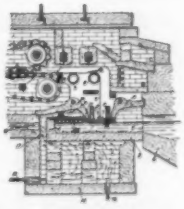
Method of and apparatus for forming sheet glass. G. E. HOWARD. U. S. 1,605,736, Nov. 2, 1926. The method which comprises directing a stream of glass toward a relatively wide sheet-forming member, and dividing the stream into a plurality of laterally spaced portions, at a point in advance of its engagement with the member.

Glass-molding machine. A. H. TYSON. U. S. 1,605,797, Nov. 2, 1926. In molding machinery, the combination with a turn-table or revolving mechanism carrying an inclined trough which extends approximately from the center to the periphery thereof, of a spout or outlet which extends above the trough and to a point approximately coincident with the center of the table, and a plurality of molds disposed in circular form beneath the discharge end of the trough.

Glass furnace. P. G. WILLETTS. U. S. 1,605,885, Nov. 9, 1926. A glass furnace having at least a part of the glass engaging portion of its bottom composed of refractory blocks which are of greater specific gravity than the molten glass to be contained in the furnace, and which therefore cannot be dislodged by floating in the glass.

Apparatus for manufacturing glass. L. J. HOUZE, SR. U. S. 1,606,298, Nov. 9, 1926. An apparatus for the purpose set forth comprising a pair of spaced horizontally disposed agitators adapted to extend into a bath of molten glass, supporting elements for the pair of agitators, the pair of agitators being arranged parallel with respect to each other and shiftably mounted in said supporting elements, and means operable for imparting a reciprocal movement to the pair of agitators for agitating the bath of molten glass.

Sheet-glass-drawing apparatus. A. E. FOWLE. U. S. 1,606,409, Nov. 9, 1926. In combination, a receptacle containing molten glass, and a protecting and heating means for the surface glass, comprising a cover plate for the receptacle and exposed electric heating elements mounted on the plate above the molten glass and out of contact therewith.



Method of making flower-vase inserts. A. J. BENNETT. U. S. 1,606,687, Nov. 9, 1926. The herein described method of making flower inserts, which consists in pressing a mass of glass into the form of a hollow body and in confining the axial and lateral movements of the mass to form a series of spaced spikes extending axially outwardly from an end of the body, then in heating the spikes and individually bending same inwardly to lie laterally of the body and with their sides spaced and with their tips arranged in a circular series surrounding the axis of the body.

Making sheet glass. H. F. CLARK. U. S. 1,606,750, Nov. 16, 1926. Apparatus for making sheet glass, including a plurality of smooth slabs pivotally connected to form a chain, sprockets for such chain, and means for driving one of the sprockets at varying angular velocity to provide uniform linear velocity for such chain, substantially as described.

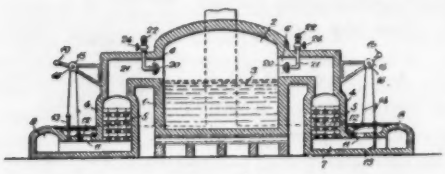
Glass-molding machine. H. J. HAYS. U. S. 1,607,078, Nov. 16, 1926. A mold for molding sheets or plates, comprising a back plate and a front plate, said plates being spaced apart to form a mold cavity, suction means associated with the mold plates for drawing molten glass into the cavity between the plates, means for moving and maintaining the plates apart to a greater extent than the thickness of the finished sheet or plate to permit the ready entry of the glass into the mold cavity during the charging operation, means for moving the plates together after the charging of the mold cavity to compress the glass between the plates to completely fill the mold cavity, and means to move the plates apart to discharge the finished sheet or plate from the mold.

Glass-blowing machine. A. N. CRAMER. U. S. 1,607,607, Nov. 23, 1926. The combination with a mold, of means to support a bare blank of glass in position to be enclosed in the mold, and means for centering the blank in said position comprising, in combination, a centering arm, fingers carried thereby, automatic means to move the arm to operative position in relation to the blank where the latter is supported by the supporting means, and means to effect a relative movement of the fingers into and out of operative position.

Glass-forming machine. H. A. ROHRICH. U. S. 1,607, 643, Nov. 23, 1926. In a glass-forming machine, means for chilling corresponding sides of a plurality of suspended charges of molten glass in plastic form, the means including an elongated body having a set of longitudinally spaced slot-like orifices along one wall.

Glass-blowing machine. L. D. SOUBIER. U. S. 1,607,651, Nov. 23, 1926. In a glass-gathering machine, the combination of a mold, means to gather a charge of glass by suction through the lower end of the mold, means to move the charge bodily upward and compact it in the mold by air pressure applied in the mold beneath the charge, means to form an initial blow opening in the upper end of the charge, and means to expand the glass downward by air pressure applied through said blow opening. A glass-forming machine comprising the combination of a rotary mold carriage, a mold thereon, a gathering tank over which the mold is carried by the rotation of the carriage, means for causing the mold to gather a charge of glass by suction from the tank, means co-operating with the mold to shape the glass to an article of the finished form in which it is finally discharged from the machine and discharge it from the mold before the mold again reaches the tank, and a carrier to receive said article, carry it past the tank, and discharge it in said finished form at a point beyond the tank.

Regenerative glass furnace. WILLIAM WESTBURY. U. S. 1,608,150, Nov. 23, 1926. A glass-melting furnace having a flame and exhaust flue at each side thereof, a burner associated with each flame and exhaust flue, a regenerating chamber at each side of the furnace, one for each flame and exhaust flue, a horizontal flue leading from the base of each regenerating chamber and having an air-intake opening, a stack tunnel with which each horizontal base flue communicates, a valve controlling the air-intake opening of each horizontal base flue, a valve for controlling and cutting off communication between each horizontal base flue and the stack tunnel with which it connects, and means for opening either valve and simultaneously therewith closing the other valve of the pair of valves associated with each horizontal base flue.



Apparatus for feeding glass. H. B. LAWSON. U. S. 1,608,326, Nov. 23, 1926. Glass-feeding apparatus, comprising a source of molten glass having a flow opening, a movable receiver normally in the line of flow through the opening, a stationary receiver

thereabove, means for moving the movable receiver out of the line of flow, and means for supplying a lubricant between the movable and stationary receivers, substantially as described. Operating means for a glass feeding apparatus, comprising a fluid pressure cylinder, a plurality of pistons therein, and means for effecting differential piston movements, substantially as described.

Heavy Clay Products

The spalling of bricks. F. W. PRESTON. *Jour. Amer. Ceram. Soc.*, 9 [10], 654–58 (1926).—Spalls in spalled bricks are under the conditions postulated by F. H. Norton, tensile, not shear fractures. The surface of separation bears no simple relation to the isothermal surfaces. In a "semi-infinite" slab, the diffusivity has no influence on the tendency to spall, but does influence the location of the surface of parting.

A successful application of powdered coal as a tunnel kiln fuel firing hard fired common brick. FRANK M. HARTFORD. *Jour. Amer. Ceram. Soc.*, 9 [10], 684–89 (1926). —The application of powdered coal by means of a non-circulating unit system to the successful firing of common brick in a continuous car tunnel kiln.

Mineral paving blocks, artificial and natural materials. BIGOT. *Rev. Mat. Constr. Trav. Pub.*, **201,** 132B (1926).—Requisite properties for a good block are: (1) wear after 6,500 revolutions on Orhy machine less than 1 cm., (2) resistance to 60 impacts without fracture, (3) compressive resistance of 1500 kg. per sq. cm., (4) d. about 2.5. Quartzites give the highest values for mechanical resistance, paving stone wears 3 times as fast, granite has intermediate wearing qualities, while basalt has a very high wearing rate. Porosities are quartzite 0.94 %, stone 9.60 %, granite 0.77 %, arkose 2.10 %, basalt 2.25 %, measured by filling the pores with kerosene. In America, artificial paving block are manufactured from schistose clays by the plastic method, whereas in France they are made both by the plastic method and by the dry (humidified) press method.

	American brick	French brick				Hydraulic
		Plastic		Press.		Press.
Wear resist.	1.33	1.60—2.20		1.86—1.50		0.68
Resist. to impact (no. of blows)	33	34	17	50	50	68
Resist. to crushing kg. per sq. cm.	1,530	1,265	710	2,600	1,848	3,200
Density						2.46

The porosity is 14–20 % for the plastic, 11.50–7.6 % for the ordinary press, and 6.20 % for hydraulic press mat. From microscopic studies it is emphasized that the heating and cooling should be slowly carried out. L.N.

Fire and load test equipment for bearing walls. C. A. MENZEL. *Eng. News. Rec.*, **97** [17], 664–65 (1926).—A description of furnace and loading panel for fire tests of 10x11 ft. walls while under load up to 500,000 lbs. as built by the Underwriters' Laboratories, Inc., Chicago. R.A.H.

Extrusion machine auger and die investigation. ANON. Bur. Stand., *Tech. News. Bull.*, No. 115, 6 (1926).—Further study has been made on the workability of clay and shale with the view of obtaining a clay or shale that would stand repeated pugging and extrusion without materially affecting the properties that govern their workability. Two clays, a brick shale from central Md. and a brick clay from eastern Md. were used in these tests. The workability of the brick shale decreased 195 % for a decrease of 8.6 % in moisture, could be extruded only twice. The workability of the brick clay remained practically constant during 3 or 4 extrusions with moisture content kept within 1½ % of dry material by weight. After 6 extrusions workability changed 32 % for a moisture change of 7.7 %. This clay is considered satisfactory for further studies of operation of extrusion machine. R.A.H.

Tentative specifications and tests for hollow fired-clay fireproofing, partition and furring tile. *A.S.T.M. Tent. Stand.*, 271–75 (1926); Ser. Designation, C 56–26 T.—Requirements as to classification, weights, dimensions, fire resistance, workmanship and finish, marking, inspection, rejection and acceptance are outlined. Description of tests such as sampling, weight determinations, strength, and absorption are given. Criticisms invited. R.A.H.

Tentative specifications and tests for hollow fired clay floor tile. *A.S.T.M. Tent. Stand.*, 276–80 (1926); Ser. Designation, C 57–26 T.—Requirements as to classification, weights, dimensions, fire resistance, workmanship, marking, inspection, rejection and acceptance are outlined. Description of tests such as sampling, weight, strength, and absorption are given. Criticisms invited. R.A.H.

Tentative specifications for fire tests of building construction and materials. *A.S.T.M. Tent. Stand.*, 281–89 (1926); Ser. Designation, C 19–26 T.—Scope of methods given. Requirements as to control of fire tests, classification as determined by test, test structures, samples, conduct of fire tests, tests of bearing walls and partitions, non-bearing walls and partitions, columns, floors and roofs and tests of finish for walls, partitions, and ceilings are outlined. R.A.H.

Value of research work to the industry. J. T. HOWINGTON. *Brick Clay Rec.*, **68,** 548–49 (1926).—The results of tests carried out at the Bureau of Standards on the properties of hollow tile should prove of great value to the industry. Standard specifications for hollow tile which the A. S. T. M. is ready to adopt will have a place in the building code of cities and results in a readjustment of fire insurance rates on this type of construction. F.P.H.

Something new for sewer pipe press. ANON. *Brick Clay Rec.*, **68,** 622–23 (1926).—A description of an apparatus for breaking up air pockets and laminations and distributing them throughout the tile by means of 4 cross-pieces mechanically revolved just above the die in the press. F.P.H.

Drying at Pacific Clay Products. F. A. MCCANN. *Brick Clay Rec.*, **68,** 865–66 (1926).—Humidity drying decreases drying time to 48 hrs. The old method of drying on hot floors required from 8 to 10 days. F.P.H.

Common brick withstands fire tests. ANON. *Brick Clay Rec.*, **68,** 939–40 (1926).—The results of the competitive tests made upon common brick and concrete blocks in Calif. show that the blocks fail to measure up to the standards set by the brick in regard to compressive strength and water absorption. As a result of these tests the building restrictions placed upon concrete block construction were not changed. F.P.H.

The strength of brick. D. KNICKERBACKER BOYD. *Brick Clay Rec.*, **68,** 943–57 (1926).—B. urges that separate specifications for brick be made which will take into account the following factors: (1) kind of clay from which they were manufactured, (2) the particular use for which they were intended, (3) modulus of rupture, (4) dry and saturated strength, (5) rate of absorption, (6) strength of the mortar, (7) method of laying, (8) tensile strength, and (9) climatic conditions of the locality in which they are to be used. F.P.H.

Promotional Bureau to further use of hollow tile. ANON. *Brick Clay Rec.*, **69** [9], 651 (1926).—The purpose of this Bureau is to provide authentic information obtained through research, thorough investigation and analysis, to architects, engineers, and contractors concerning the best practice and economical use of surface clay tile, and to develop new fields for its use in building construction. F. P. H.

The Miami disaster as viewed by an engineer. L. B. LENT. *Brick Clay Rec.*, **69** [9], 652–54 (1926).—L. states that flimsy construction is responsible for the vast number of buildings wrecked and the consequent heavy loss of life. Types of construction which engineering principles and years of experience have demonstrated to be sound

withstood the storm with commendable fidelity. The obvious remedy is a rigid enforcement of the building code together with a slight revision. F.P.H.

Formulating standard building material fire tests. ANON. *Brick Clay Rec.*, **69** [9], 654 (1926).—The fire resistance of building constructions and materials is to be expressed in time periods of ultimate resistance when subjected to fire exposure, the intensity of which is controlled according to a definite furnace time-temperature curve. As a result of experiments carried out at the Bureau of Standards new standards for fire tests of bearing walls and partitions, and ceiling and partition finish have been formulated. The revised specifications have been published by the Nat. Fire Protection Assn. and the A. S. T. M. F.P.H.

Survey proves worth of thin pavers. L. W. TELLER AND J. T. PAULS. *Brick Clay Rec.*, **6**, 655–60 (1926).—The data submitted in this article supplement the Arlington road tests. A report of how thin paving brick have stood traffic on streets in different cities throughout the country. Such factors as construction, age, climate conditions, traffic, and maintenance, were considered. In the majority of the roads examined the thin pavers stood up remarkably well. F.P.H.

Strengthening clay ware bodies. B. W. WILLSON. *Brick Clay Rec.*, **69** [10], 740–41 (1926); (an abstract of Rept. No. 60 V of Mellon Inst. Indus. Research).—A report of laboratory tests of 5 materials which are on the market and advertised as body strengtheners for clay products is presented. The materials are organic gums or sugars. Results show that the addition of varying amounts of these strengtheners increased the strength of the dry ware from 5.7 to 56.6 % and of the fired ware from 5.7 to 28.6 %. A series of tests carried out at a sewer pipe plant under regular operating conditions showed an increase in the green and fired strength. F.P.H.

The economy of brick pavements. ANON. *Brick Clay Rec.*, **69** [10], 747–48 (1926). F.P.H.

270,000 face brick daily. ANON. *Clay-Worker*, **86** [4], 283–92 (1926).—Description of the new No. 3 Unit of the Alliance Clay Products Co. F.P.H.

The A.S.T.M. specifications for building brick. W. C. KOCH. *Clay-Worker*, **86** [4], 308–309 (1926).—K. states that the compression and transverse tests have a direct relation to the use of the material and disclose properties which are actually required in practice. The results of the absorption tests, on the contrary, are far removed from the properties sought to be evaluated. Three types of weathering are recognized: those due to erosion, spalling, and lime pebbles. Absorption is not a measure of the degree of firing since almost any degree of absorption may be obtained artificially or by selection of raw materials, all with the same degree of firing. K. concludes (1) that the absorption test is not a measure of the durability of brick, (2) it gives some slight amount of information but the modifications required to reduce this information to a workable basis are of greater significance than the tests itself. F.P.H.

Paving brick tests. ANON. *Clay-Worker*, **86** [4], 312–13 (1926).—The results of the tests on the 2½-inch pavers as carried out by the Bureau of Public Roads. The investigation covered 3 lines: (1) field survey of 3½- and 2½-inch brick-wearing surface now in use, (2) accelerated traffic test of various thicknesses of paving brick on a special test track at Arlington, Va., (3) laboratory tests on physical properties of the various types of brick. Results on the Arlington road tests have been published and indicate that the 2½-inch pavers of the quality used there, when properly supported, will prove satisfactory for pavements carrying the heavier types of traffic. The 2-inch pavers when properly supported will be adequate for pavements carrying the lighter types of traffic. A bedding course of plain sand is more effective in reducing breakage of brick than a cement-sand bedding course. F.P.H.

Pitting of tiles at the seaside. R. L. JACK. Geol. Surv. S. Australia, *Bull.*, 16–18, No. 12 (1926).—Pitting and exfoliation of some varieties of roofing tiles at the seaside has been investigated by W. S. Chapman. Analyses were made of 7 tiles and results are given. The usual cause of pitting and disintegration of clay tiles or brickwork when exposed to the alternate action of a salt-laden moist atmosphere and strong sun, is that the salts, chiefly sodium and magnesium compounds, in a state of solution are absorbed by the tile, according to the porosity of the tile. Under the action of strong sunlight certain of the salts crystallize out, and in doing so a mechanical strain is exerted on the particles of the tile in proximity to the pore in which crystallization occurs; a succeeding wave of moist air redissolves the crystals, which are in turn recrystallized by the following hot wave. This results in disintegration of the tile. On reference to the table of analyses, "Total water soluble salts, other than calcium sulphate" it will be seen that the 2 pitted tiles alone contain an appreciable percentage of such salts. Calcium sulphate of much lower solubility than the usually accepted "water soluble salts," is not shown in the analyses. Owing to insufficient water being used to effect its complete solution, the calcium sulphate present in the tiles would be chiefly due to gypsum naturally present in the clay or added to it before firing. At the temperature at which the tile is fired this gypsum would be "dead burnt," in which form it would not rehydrate, and would not act in the manner of the salts. French tiles containing free lime when freshly fired, did not contain any free lime, but the analyses show a large proportion of calcium and some carbon dioxide. The lime present in combination with this carbon dioxide may have at the time of removal from the kiln been present as quick (free) lime which has subsequently, on exposure to the atmosphere, become dehydrated and then carbonated; or it may have been derived from the action of the atmospheric carbon dioxide on calcium amd magnesium salts collected from the seaspray. The amount of carbon dioxide found in the unused tile does not favor this explanation and the carbonate found in the analyses is probably a portion of the original calcium carbonate that was present in the tile before firing. The high lime and the carbon dioxide content of the French tile does not have any direct bearing on the pitting. Absorption tests were made by taking a sound piece of each tile, 2 by 3 in. These were dried, weighed, and immersed in water for 24 hrs., allowed to drain, weighed, and the increase of weight due to absorbed water calculated to the percentage on the dry piece. The results have a comparative rather than an absolute value. The results obtained from the above tests were favorable to the S. Australian tiles. J. determined the hardness of the face or skin of the tile in terms of the Moh's scale of hardness. The hardness, which is due to vitrification, or superior density due to high temp. for any particular clay, controls the amount of absorption of water, and that on the amount of absorption depends the quantity of salts that can be introduced into the body of the tile. The cure for fretting at the seaside is thorough firing, so that there is incipient vitrification and development of density in the tile, especially on the surface. The hardest fired and the least absorbent tile should be the most satisfactory from the point of view of resistance to disintegration and permanency.

O.P.R.O.

Marking of building brick imported into Canada. ANON. *Ind. Can.*, **27**, 74 (1926).—By Dominion Order-in-Council, effective October 15, 1926, it is provided that imported brick must be marked with an indication of the country of origin. Printed and lithographed matter, including books and pictures, and wooden or fiber lead pencils, are also required to be marked.

H.H.S.

Refractories

A study of the shrinkage of diaspor clays. I. S. M. PHELPS. *Jour. Amer. Ceram. Soc.*, **9** [10], 659–66 (1926).—Diaspor refractories often possess the undesirable char-

acteristic of continual shrinkage in service, and since it is not practical to alter such properties in the present manufacturing processes, the object of this study was to devise, if possible, a manufacturing process to overcome this shortcoming. This part of the paper reveals the mechanism of the firing shrinkage and describes the effect of particle size, time, and temperature upon the shrinkage of diaspor clays of various compositions. The properties of the two major constituents of a typical sample are given, as well as photomicrographs of interesting samples. Part II will describe experimental work conducted to devise shrinkage processess and the properties of the products so made.

Specifications for lining and checker brick for water-gas manufacture. E. J. BRADY. *Jour. Amer. Ceram. Soc.*, **9** [10], 667–78 (1926).—Specifications are given for all refractories used in water-gas manufacture based on U.G.I. experience. Description of equipment, operation, and conditions are given.

Silicon-carbide refractories for water-gas generators. M. L. HARTMANN AND JOHN A. KING. *Jour. Amer. Ceram. Soc.*, **9** [11], 758–65 (1926).—A discussion of the problems involved in water-gas generator refractories is given and the steps in the development leading to the present highly satisfactory silicon-carbide air-ventilated Bernitz type blocks are given. Actual operating costs of typical installations are given. It is shown that generator capacities have been increased as much as 50 % and fuel reductions have been so large that a real saving in net operating costs has resulted from the installation of this type of lining. Many generators have now been lined and economically operated with air-ventilated silicon-carbide blocks.

Contribution to the study of silica brick. WIDEMANN. *Rev. Mat. Constr. Trav. Pub.*, **201**, 133B (1926).—The properties required to be known are, for the raw mats.: chemical analyses, firing tests, study of density and microstructure, study of conditions of transformations by suitable firing tests; for the finished products: in addition to the above tests, those of mechanical resistance, expansion changes with heat, abrasion while both hot and cold, conductibility, specific heat and resistance to heating. The service given by a good silica brick will depend upon whether it is designed to be placed in position in a hot furnace, or whether it is designed to be placed in a cold place and then gradually brought up to temperature. The minimum percentage of silica in the raw mats. (*i. e.*, the permissible impurities) to be allowed depends upon the condition of the final product. L.N.

Cost estimating and cost records in the firebrick industry. G. BERGAU. *Feuerfest*, **2** [7], 65 (1926).—A discussion of cost records necessary for correct estimating with special reference to the manufacture of standard brick and shapes. F.A.W.

Refractory materials for coking chambers and gas plates. L. LITINSKY. *Feuerfest*, **2** [9], 81 (1926).—Detailed discussion of the following important properties of refractories used for this purpose: (1) refractoriness, (2) resistance to load under high temperature, (3) volume changes at high temperatures, (4) low coefficient of expansion, (5) resistance to slag and corrosion, (6) thermal conductivity, (7) resistance to thermal shock, (8) porosity, (9) mechanical strength. F.A.W.

Tentative method of test for resistance of fireclay brick to spalling action. *A.S.T.M. Tent. Stand.*, 308–309 (1926); Ser. Designation, C 38–26 T.—The object of the test is described followed by a description of method of preparing samples and procedure to be followed. Criticisms invited of revised test. R.A.H.

U.S. Government Master Specification for refractories, fire clay, plastic. ANON. Bur. Stand., *Circ.*, No. 297, Oct., 1926.—The material covered by this specification is essentially a mixture of grog, raw clay, and sufficient water to render the mass plastic and of a stiff-mud consistency. The material furnished under this specification shall be of one grade only. The requirements as to silica content, softening point, water content, shrinkage, and Navy Simulated Service Test are stated. Definite instructions as to method

of inspection and tests are given with a note on packing and marking of containers used for shipping this material. R.A.H.

U.S. Government Master Specification for clay, fire. ANON. Bur. Stand., *Circ.*, No. 298, Oct., 1926.—This specification covers a heat-resistant material composed entirely, or principally, of fire clay and which is used in laying up fireclay refactories. Fire clay shall be of 2 classes: (F) fine, (C) commercial. The requirements as to fineness, bond, softening point, and Navy Simulated Service Test are enumerated. Definite instructions as to method of inspection and tests of these requirements are given with a note on packing and marking of containers used for shipping such clay. R.A.H.

Elasticity and transverse strength of clays at elevated temperatures. ANON. Bur. Stand., *Tech. News Bull.*, No. 115, 6–7 (1926).—An apparatus has been developed to determine rapidly and with satisfactory accuracy the moduli of elasticity and rupture of representative sagger and refractory clays at various temperatures up to 1000° C. The apparatus consists essentially of 3 parts: (1) the furnace, (2) the lever arm below the furnace through which the load is applied to the specimen, (3) the gages and support on which the gages are mounted. The clay specimen rests on knife edges and any deformation obtained through strain applied at the center of the specimen bar is transmitted by means of fused quartz rods to micrometer gages placed over the center and knife edges at either end. 17 sagger clays have been tested both at room temperature and at various higher temperatures. 13 clays were found to have greater transverse strength and 4 clays a lesser strength at the higher temperatures. Moduli of elasticity ranged from 706,000 lbs./in.^{2} to 8,040,000 lbs./in.^{2} with all but 2 clays showing a higher value at the higher temperatures. R.A.H.

Tank block problem solved at Corning. ANON. *Glass Ind.*, **7** [11], 257–61 (1926).—The recent development of cast tank block made of a composition of about 70 % alumina and the rest largely silica, melted in an arc furnace and cast in a sand mold is discussed. The development of the new cast block is traced. Due to a greater density and more compact crystal structure of the cast blocks, they are superior to fired or sintered blocks of the same composition in resistance to erosion by glasses and slags. No difficulty due to spalling has been encountered. The blocks must be cooled off very slowly to prevent cracking. Possibilities of large scale production and of the wide application of this invention are discussed. E.J.V.

Literature on refractories for the glass industry. ANON. *Glass Ind.*, **7** [11], 275–76 (1926).—A bibliography on raw materials and finished product covering the period 1914 to 1924. E.J.V.

Developments in the refractories field. ANON. *Amer. Glass Rev.*, **46** [7], 15 (1926); *Nat. Glass Budget*, **42** [28], 3 and [29], 6, 24 (1926).—Abstracts of the following papers recently prepared and delivered at different meetings are given: "Cast Glass Tank Blocks," G .S. Fulcher (*These Abs.* p. 25); "The Load Test for Fireclay Refractories," M. C. Booze :*These Abs.*, p. 23); "Mullite Refractories," T. F. Curtis (see *These Abs.*, p. 24). E.J.V.

The variation of size occurring in clay and silica refractories. S. M. PHELPS AND H. F. ROBERTSON. Amer. Refrac. Inst., Fall Meeting, Pittsburgh, Pa., Oct. 21, 1926.—A standard method of obtaining the size of brick was used. An apparatus capable of making parallelled plate measurements was designed, consisting of a base plate above which a second plane plate was mounted so as to move, parallel to the base any distance up to 10 in. An Ames dial was fixed to the movable plate and indicated at any time the distance the two plates are apart. Such a method included in the dimension the effects of warpage and swelling and gives an overall size which is the largest that can be obtained by any method of measuring. The plant study consisted in measuring 55 types of brick making over 10,000 single measurements. The following dimensions are the average of all brick measured.

	Length	Width	Thickness		Length	Width	Thickness
Hand-made	$9\frac{1}{32}$	$4\frac{13}{32}$	$2\frac{13}{32}$	Dry-press	$9\frac{1}{16}$	$4\frac{13}{32}$	$2\frac{9}{16}$
Stiff-mud	9	$4\frac{11}{64}$	$2\frac{17}{32}$	Average	$9\frac{1}{32}$	$4\frac{13}{32}$	$2\frac{9}{16}$

A size tolerance is suggested, namely: not more than 10% of the brick in a shipment shall vary by more than $\frac{1}{16}$ in. in thickness, $\frac{1}{16}$ in. in width and $\frac{1}{2}$ in. in length from the average. Inspection shall be made of 50 brick taken at random from the shipment and each brick shall be measured for length and thickness by means of an approved device, which would consist essentially of 2 adjustable plane parallelled plates between which the brick is placed for measurement. F.P.H.

The load test for fireclay refractories. M. C. Booze. Amer. Refrac. Inst., *Tech. Paper*, No. 2.—Ultimate failure of refractories may take place because of spalling, slag erosion, shrinkage, fusion, abrasion, mechanical breakage, or softening either by heat alone or through acceleration by mechanical stresses. It is usually the case that several of these factors act in conjunction, although any one may be instrumental in bringing about destruction. Slag erosion and spalling are the most important factors. The test for deformation under load is a popular one, but the results are often misused because they are interpreted as indicating suitability for all classes of service. The load test should be limited to the selection of brick for furnace parts where deformation is the most important cause of failure. From the findings of one test, however, the strength at higher and lower temperatures cannot be predicted accurately. The test will only be of value provided the test conditions simulate those of service. Deformation under load bears no relation or only an indefinite one to the various causes of failure described and the test should not be used as a single test to determine the suitability of fireclay brick for service in furnaces where a variety of conditions exists. Deformation is not apt to be an important cause for failure of fireclay brick in a furnace wall, and will occur only when a high temperature is developed at a considerable depth in the wall. Charts are given showing the effect of temperature and pressure on the deformation of fireclay brick. F.P.H.

Tentative specifications for clay firebrick for malleable furnaces with removable bungs and for annealing ovens. Amer. Refrac. Inst., *Tech. Bull.*, No. 3, Sept., 1926.—Specifications covering the following are given: (1) size tolerance, (2) bungs, (3) sidewalls and bridgewalls, (4) fire box linings and lower stack linings, (5) upper stack lining, (6) annealing oven fire box, (7) annealing oven chamber. The following methods of testing are given: (1) determination of silica content according to A. S. T. M. standard method, serial designation, 18–21, (2) Softening point according to A. S. T. M. standard method, serial designation, C–24–20. (3) Spalling test shall be conducted on standard 9-in. straight brick, or standard 9-in. or 13-in. bung brick. This test shall be conducted as follows: The brick as received at the testing laboratory shall be heated in the door of a suitable furnace which is being held at a temperature of 1350°C (2462°F). The heated end of the brick shall be flush with the inner face of the furnace wall and the outer ends shall be exposed to the free circulation of air. At hourly intervals the hot ends of the brick shall be immersed in running water to a depth of 2 in. for 3 min. The brick shall then be removed, allowed to steam in the air for 5 min. and returned to the furnace door. This cycle shall be repeated until each brick shall have lost the required amount or until total number of immersions necessary to give the required average has been obtained. Individual samples are not to be continued in the test after a loss of 20% has been sustained. The brick shall be dried and weighed before and after testing and the loss computed in per cent of the original dry weight. (4) Modulus of rupture according to A. S. T. M. standard method, serial designation, C 21–20. The specifications do not include a requirement for slag resistance as none of the slag tests that have been proposed can be regarded as satisfactory for malleable practice. Revision of the requirements is

to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. F.P.H.

Fire cone 28 mullite brick in tunnel kiln. THOMAS S. CURTIS. *Ceram. Ind.*, **7** [5], 464–65 (1926).—The object of this high temperature was to bring about a recrystallization of mullite in the body of super-refractory brick made from Calif. mullite without clay bond. The natural mullite ore was brought to a condition of intermediate plasticity by fine grinding and the inclusion with it of sufficient bacteria-forming organic material to simulate moderately plastic clay. 20% of this artificial clay was mixed with 80% of Calif. mullite grain, the grain being properly graded. This mixture was dry pressed in a standard Fernholtz press and fired in a tunnel kiln at cone 28. F.P.H.

Refractories service conditions in furnaces burning Pittsburgh coal on chain grates. RALPH A. SHERMAN AND W. E. RICE. *Mech. Eng.*, **48** [11], 1115 (1926).—This report presents data obtained as a part of the investigation of the proper application of boiler-furnace refractories which is being conducted by the Bureau of Mines in coöperation with the special research committee of the A. S. M. E. on boiler-furnace refractories. A full interpretation of the data has not been attempted. The report is accompanied with many tables, curves, and photos. The stokers and coal are described. Among the data obtained are refractory temperature, furnace gas temperature, and composition, SO_2 and SO_3 content of gases, and coal ash and slag composition. C.J.H.

What is good fire brick? HUGH E. WEIGHTMAN. *Power*, **64** [14], 508 (1926).—The fusion point is the first specification considered. A softening point of 3000°F is sufficient for boiler refractories. Similar conditions of atmosphere, same rate of rise of temperature, same dimensions of cones, same fineness of texture of samples, and same fuel must be used if results are comparable. A chemical analysis is of assistance in judging the quality of fire bricks only when accompanied with a petrographic analysis. Silica in fireclay refractories combines with accessory minerals to form silicates; an excess of silica permits free silica to be present which is usually detrimental. Excess alumina is an advantage in that stony, more refractory combinations result; when brought to its softening point, the formation is more viscous and less likely to deform. Excess alumina requires that the refractory be fired to at least 2500°F. Kaolin is the clay combination for the best refractories. A useful method of comparing fire brick is by the load test; an illustration and curves are given of a representative test. The spalling test is another useful method of comparing fire brick. The Navy test is described.

C.J.H.

Choosing and testing fire brick. HUGH E. WEIGHTMAN. *Power*, **64** [15], 549 (1926). Testing a fire brick by placing it on the bridge wall or in the furnace wall may lead to erroneous conclusions. A test of texture and firing of a refractory is that of examination under a microscope after firing for 10 hours at maximum furnace temperature; a glass formation should not extend into the brick more than 0.1 in. A visual inspection of refractories should include dimensions, texture, and hardness. The texture of a brick will vary with the kind of fuel used, the firing apparatus, the character of the clay, and the process of manufacture. Examples are given of how the texture may be varied. Furnaces using oil or powdered coal require the mechanical texture of the brick to be as fine as possible. The hardness of firing has a great deal to do with the life of the furnace. For best fire brick the limitations in the specifications should be right.

C.J.H.

Firebrick specifications. ANON. *Power*, **64** [15], 561 (1926).—*Bulletin* No. 3 of the American Refractories Institute is discussed. (See *These Abs.* p. 23.)

C.J.H.

Repairing leaky baffles with a refractory gun. P. R. INGLIS. *Power*, **64** [15], 564 (1926).—The repair of baffles with refractory cement put on by means of a gun is described. The composition of refractory mixtures is given. C.J.H.

Diatomaceous earth casting, slop molding, and casting bodies. A. E. MacGee and Harold E. Simpson. *Ceramist*, **8** [7], 445–50 (1926).—The composition and method of preparation of several diatomaceous earth bodies which are light in weight, good heat insulators, relatively soft and highly resistant to sudden temperature changes are described. The bodies will stand temperatures as high as 1100°C and are especially desirable where complex shapes and close fits are required. Several shapes used by M. and S. have been removed at least 1000 times from a furnace at about 1000°C and allowed to cool to room temperature without showing any ill effects. Photographs of articles made from these bodies are given. The bodies and the procedures used in casting, slop molding, and puddling ware are described as well as the drying and firing procedure. The properties of the finished ware are described and illustrated by means of charts. A.E.R.W.

Refractories for melting pure metals: iron, nickel, platinum. Louis Jordan, A. A. Peterson, and L. H. Phelps. *Fuels and Fur.*, **4** [11], 1254 (1926).—Abstract of a paper by above authors, presented at the meeting of the Amer. Electrochem. Soc., Washington, D. C., October, 1926. A discussion of the results of an investigation to determine the materials best suited for the melting of iron, nickel, and the platinum metals of a high degree of purity on a laboratory scale. A.E.R.W.

Effect of the open-hearth process on refractories. F. W. Schroeder and B. M. Larsen. *Fuels and Fur.*, **4** [11], 1333–34 (1926).—The effect upon the brickwork of the dust and fumes given off from the charge and the molten bath depends upon the temperature, atmosphere, and position in the furnace structure in regard to gas flow. The dust content is high near the end of the charging period and during the lime and ore boils. Analyses of the dusts showed iron oxide 50–90%, lime 0–20% and small amounts of Mn_3O_4, MgO, and SiO_2. Little dust comes from the slag or from the ore charged for oxidation. A "fume" of small iron oxide particles is formed from the iron vapor given off from the fluid steel. In a well-designed furnace, the roof and walls in the melting chamber suffer slow and uniform corrosion. Slagging corrosion is more rapid at the port and port-end wall surfaces. Corrosion of brick occurs only in overheated checker chambers. The important causes of failure for the different parts of basic open-hearth furnaces are listed. A.E.R.W.

Cast refractory blocks give highly satisfactory service. G. S. Fulcher. *Fuels and Fur.*, **4** [11], 1339–40 (1926); (abstract of a paper by F., presented at the meeting of the Amer. Refrac. Inst., Pittsburgh, Pa., Oct. 21, 1926).—Cast refractories, made by the newly developed method of melting in an electric furnace and pouring into molds, show remarkable resistance to erosion in glass tanks. The experimental development method of casting, composition, physical properties, and cost of melting of the cast refractories are discussed. A.E.R.W.

Refractories for induction furnaces. M. Unger. *Fuels and Fur.*, **4** [11], 1359–60 (1926).—Reasonably pure magnesium oxide bonded with a commercial pitch of very low water content was found to best fulfil the refractory requirements of a single-phase induction furnace for melting steel, the design of which is given. Graded sizes of fused magnesium oxide were used in order to obtain maximum density and certain percentages of unfused magnesium oxide were added to lower the expansion of the lining. The lining has been used continuously for 7 years. The proportions in which the materials are mixed, the analysis of the fused magnesium oxide, and the properties of the pitch are given. The method of installing the lining and the service which it renders are described. A.E.R.W.

The basic open-hearth furnace charge. Paul H. Shaeffer. *Fuels and Fur.*, **4** [11], 1365 (1926); (an abstract of a paper presented at the Pittsburgh meeting of the A.I.M.M.E., Oct. 25, 1926).—Reference is made to the refractory materials used in repairing the bottom and banks of an open-hearth furnace. A.E.R.W.

An application of recrystallized silicon carbide (in porcelain kilns). F. A. J. FITZGERALD. *Trans. Amer. Electrochem. Soc.*, **50,** (preprint), 6 pp. (1926).—A refractory for certain electric furnaces developed for the firing of porcelain at high temperatures. The electric resistors in these furnaces are made of graphite, and are enclosed in gas-tight resistor chambers separated from the chambers in which the porcelain is fired by a septum which forms the floor of the resistor chamber and the roof of the firing chamber, through which the heat is conducted from the resistor chamber and thence radiated to the ware. This design is necessary because during the firing of the porcelain an oxidizing atmosphere is required, obviously an impossible condition with a graphite resistor in the same chamber. The firing temperature is high, in some of the work reaching at least 1570°. The specifications for the septum are: 1. High heat conductivity, so as to avoid an excessive difference of temperature between the resistor and firing chambers. 2. No softening of septum with consequent distortion when highly heated for long periods. 3. Resistance to deterioration when heated to a high temperature in the strongly reducing atmosphere of the resistor chamber. 4. Resistance to deterioration when heated to a high temperature in the strongly oxidizing atm. of the firing chamber. The refractory which proved most promising for this work was recrystallized SiC. Articles of recrystallized SiC are made by mixing with granular or powdered SiC a temporary bonding substance, such as glue, molding into the desired form and then heating in a furnace to a temperature equal to that at which silicon carbide is formed, approximately 1800°. (*C. A.*)

Thermal insulation of electric furnaces. (A new fireclay refractory.) M. L. HARTMANN AND O. B. WESTMONT. *Trans. Amer. Electrochem. Soc.*, **50** (preprint), 25 pp. (1926).—The thermal conductivities of fused Al_2O_3, fused MgO, fireclay, and a new high-temperature insulating fireclay refractory are given in addition to the published data on Carborundum and SiO_2. Mean specific heat curves for these refractories are also given. The temperatures, heat losses, and heat capacities of 13 types of electric furnace linings are tabulated, with the inside surface temperatures assumed to be 1600°, 1400°, and 1200°. The object of this paper is to suggest possibilities of energy conservation in electric furnaces by properly designed composite walls. The data presented emphasize (1) the importance of considering the heat capacities of walls under specific temperature conditions, (2) the great value of refractory insulating materials in preventing heat losses without increasing the capacity of a furnace lining to absorb and store heat. Heretofore no material was available which would withstand the high temperatures back of thin "super" refractory linings. In the past it has been necessary to use a thicker inner lining, with consequent greatly increased heat capacities and larger exterior furnace surface with increased radiation losses. With the introduction on the market of the new fireclay refractory insulating material, which can be used up to 1450°, it is now possible to make relatively thin electric-furnace linings without the heat losses usually caused by such practice. (*C. A.*)

Service conditions of refractories for open-hearth steel furnaces. B. M. LARSEN, F. W. SCHROEDER, E. N. BAUER, AND J. W. CAMPBELL. Carnegie Inst. Tech., *Min. Met. Invest. Bull.*, **23,** 1–126 (1925).—Refractory service in 18 American open-hearth shops is discussed. There are given analyses of checker and tunnel-wall deposits in several furnaces, also the concentration and composition of the dust in the stack, checkers and port ends of a 50-ton basic open-hearth furnace, analyses of slag deposits and used brick taken from furnaces cooled down for rebuilding after a campaign of steel making, time-temperature, and temperature gradient curves of furnace walls, and tables showing temperature distribution in the melting chamber. The probable causes of failure of refractories in open-hearth furnaces, and furnace design as it affects service of refractories are discussed. (*C. A.*)

Vitreous silica and vitreous quartz. W. W. WINSHIP. *Trans. Amer. Electrochem. Soc.*, **50** (preprint), 12 pp. (1926).—Indifference to corrosion of vitreous SiO_2 wares, even at high temperature except under basic conditions, renders them suitable for such operations as high-temperature reactions with phosgene, purification of gases, preheating ammonia-air mixture in ammonia oxidation processes, handling high-strength H_2O_2 solutions, and for conducting concentration, absorption, and cooling processes with acids. A recently designed HCl-absorption vessel of fused silica has shown high efficiency. Articles of fused silica grains bonded by gelatinous silica possess properties which promise usefulness in various fields, retaining the small coefficient of expansion which is characteristic of fused silica itself. An interesting application of fused quartz outside the chemical field is as the frangible bulb of automatic sprinkler heads for fire extinguishing, the bulb having to stand great extremes of temperature during the sealing process required to confine the bursting charge of volatile liquid. (*C. A.*)

The thermal expansion of some fused oxides used as refractories. G. E. MERRITT. *Trans. Amer. Electrochem. Soc.*, **50** (preprint), 10 pp. (1926).—The thermal expansions up to 900° of the oxides of Si, Th, and Zr, of a mixture of one-to-one molecular proportions of ThO_2 and ZrO_2, and of the refractories made of MgO, Al_2O_3 and ZrO_2 were measured. The results are exhibited in graphical form and intercompared. From the "S" form of the curves and other evidence, it is concluded that a combination takes place when ThO_2 and ZrO_2 are fused in these proportions. (*C. A.*)

Modern viewpoints in the selection of refractories. J. L. BIENFAIT. *De Ingenieur*, 210, **1926**; *Arch. Suikerind.*, **34**, 650–59 (1926).—Chemical analysis is of little use because fire bricks of the same chemical composition may be very different in refractory properties. Physical methods of testing which are in use at present are discussed, with special reference to deformation by pressure at increasing temperature. Experiments have been made with an apparatus designed by Seger and Cramer (illustrated) for measuring, and registering on a chart the change in length of the brick section under constant pressure for each time interval. The gradually increasing temperature is determined pyrometrically and can thus be plotted directly against the change in length. For chamotte bricks there is a large temperature interval between incipient softening and collapse, while silica bricks collapse all at once when a certain temperature is reached. This test is being used more and more as a basis for specifications. (*C. A.*)

Determination of the refractory powers of clays from their water of constitution. N. P. CHIYEVSKII. *Rev. soc. russe métal.*, No. 1 (June, 1925); *Rev. métal.*, **23** (Extraits), 302–303 (1926).—A diagram shows the relation between H_2O of constitution and melting point of clays. When loss on ignition is determined it must be corrected for hygroscopic H_2O, org. matter, and CO_2 driven off. (*C. A.*)

Refractories for oil gas generators. J. T. CREIGHTON AND M. J. CEREGHINO. *Gas Age-Rec.*, **54**, 826–28, 860–62, 894–96 (1924). (*C. A.*)

PATENTS

Neutral refractory cement. W. F. ROCHOW. U. S. 1,606,481, Nov. 9, 1926. A refractory composition comprising an intimate mixture of a powdered aluminum oxide and powdered sodium silicate.

Method of making refractory articles. E. C. R. MARKS. Brit. 207,677, Brit. Cast Iron Research Assn., *Bull.*, No. 5 (1924).—Twenty per cent graphite and 80% Carborundum or similar material mixed with 15% binder (pitch, tar, etc.). Binder is fired off and articles dipped in liquid flux, such as sodium borate or silicate and annealed at 650°C., or flux may be mixed in article and reheating omitted. Flux gives strength suitable for crucibles, bricks, tiles, etc. O.P.R.O.

Manufacture of refractory bricks, etc. from dolomite or other material possessing plasticity at high temperatures. F. L. DUFFIELD. Brit. 223,616, Brit. Cast Iron Research Assn., *Bull.*, No. 7 (1925).—Granulated dolomite or other similar material, with or without fluxing agents, is pressed in bricks, etc., while in the plastic state, i.e., at about 1500°C. The molded articles are annealed slowly after emerging from the molds. O.P.R.O.

Refractory furnace linings. E. HOLLEY. Brit, 235,505, Brit. Cast Iron Research Assn. *Bull.*, No. 10 (1925).—A wash suitable for spraying on to defective furnace linings is prepared by mixing a refractory clay with a dilute aqueous solution of sodium silicate containing 16.88% NaO and 35.88% SiO_2. Any desired thickness may be obtained by alternate spraying and drying of the deposit. O.P.R.O.

Terra Cotta

Some fundamentals of terra cotta. HARRY SPURRIER. *Jour. Amer. Ceram. Soc.*, 9 [11], 773–78 (1926).—Terra cotta is not a definite material. Considerable difference of opinion exists as to suitable structure and composition. There are more differences between different makes of terra cotta than there are in opinion as to what it should be. Microscopic study of thin sections of terra cotta is a valuable method of examination. The voids in terra cotta are of more than one kind and origin. The grog used in terra cotta is frequently unsuitable as to character and size. A fuller knowledge of fundamentals will probably much alter ideas as to suitable grog. A test for internal stress is described. Terra cotta was tested for osmotic action. The internal degradation of terra cotta is demonstrated by two different methods.

Shivering. W. J. STEPHANI. *Bull. Amer. Ceram. Soc.*, 5 [11], 421–23 (1926).—Methods employed to overcome shivering are described. By reducing the china clay content 5% in full glazes and 2½% in matt it was possible to overcome shivering with the body then in use. Tests of the clays used in the body were made to find the trouble and it was found that replacement of the clay at fault with another which met the other requirements a terra cotta body must meet gives a product free from shivering. E.J.V.

White Wares

Study on the porosity and vitrification of bodies during firing. BRÉMOND. *Rev. Mat. Constr. Trav. Pub.*, 201, 134B (1926).—A study made to determine the influence of gases, as oxygen, CO_2, water vapor on the carbonaceous matter present; the action of CO_2 during the water-smoking period, variations of the length of firing-on the porosity of the ware. Tests were made on porcelain bodies from Limoges, Vierzon, Bayeux, Sèvres, and on some stoneware bodies, by firing pieces 6–8 gms. in a gas fired kiln. Porosity was measured by the weight of water absorbed. The results are: (1) up to 1050°C, no change in porosity, (2) 1050°–1100° in the feldspar bodies, porosity diminishes, (3) 1100°–1200°, feldspathic bodies lose all porosity, (4) at 1200° vitrification of lime begins, (5) at 1300° the porcelain bodies are vitrified. The stoneware bodies are comparable to the feldspathic porcelains with a lower porosity. Rapid firing has the effect of increasing the porosity: at 1200° up to 7%, from 1050–1100° up to 2–3%. Glazes show porosities greater than the bodies, and their fit to the bodies is not determined by chemical composition but by mineral constituents. There is no relation between porosity and fusibility in glazes. Bodies contain carbon obtained from the raw materials and from the dissociation of the gases of combustion. Experiments were performed on bodies of different porosities containing 1% lamp black. At 4% porosity and below, the combustion of the carbon in the bodies by 0 is arrested. The reaction $CO_2+C=2CO$ has been verified in bodies containing carbon fired in a tube furnace, with a circulation of CO_2. The carbon in the raw body is burned out, while the carbon

of the body with 4% less porosity is not burned out. The reaction $H_2O+C=CO+H_2$ has been verified also. Bodies are able to carburize themselves only above 900°; in fresh porcelain this action takes place between 900 and 1200°. Between 1200 and 1250° fluorine contained in the bodies is evolved, and fresh porcelain with 1% calcium fluoride is found always bloated. L.N.

Dr. Kohl's viscosimeter, with special reference to its adaptability to the refractory industry. H. KOHL. *Feuerfest*, **2** [6], 53 (1926).—Comparative tests of the dry strength of hand pressed and cast samples of kaolins showed the latter to have an average of double the strength of the former. On account of this and other advantages of the casting method the importance of practical application of certain scientifically established facts is stressed. Of special importance is the measurement of the rate of flow of the casting body. A description of the Kohl flow viscosimeter follows with which the water content is varied until a specified flow rate is reached. The water content necessary determines the casting qualities of the clay. Tests on refractory bodies containing coarse grog are conducted on the groundmass from which the grog has been separated by screening. F.A.W.

Development of a sanitary ware plant. E. S. HANSON. *Ceramist*, **8** [7], 467–77 (1926).—The development of the Woodbridge Ceramic Corp. from a 2-kiln to a 9-kiln plant in 8 years' time is described. A plan of the plant is used in showing the growth to its present size. Some of the present features are (1) prompt delivery by motor truck, (2) mining of the clay by the company itself, (3) plenty of light and ventilation, (4) careful preparation of glazes. An airplane view of the plant and close-ups of different parts are shown. A.E.R.W.

Tentative methods of testing electrical porcelain. *A. S. T. M. Tent. Stand.*, 801–11 (1926), Ser. Designation, D116–26T.—Field to which applicable. Requirements as to apparatus used, test specimens, mounting of specimens, procedure and report for determination of tensile strength, compressive strength, transverse strength, resistance to impact, dielectric strength, and resistance to thermal change, (*a*) porcelain for transmission line insulators, (*b*) porcelain for spark plugs and heating devices. Method for determination of porosity is also given. R.A.H.

The aging phenomena of porcelain insulators. K. DRAEGER. *Electrotech. Zeit.*, **38**, Sept. 23, 1926.—In order to determine the effect of aging of porcelain insulators, loss angle measurements, shock tests, and puncture tests under oil were made on pin type insulators which had been in service 10 years and on insulators of the same lot which had been in storage for the same length of time. New chain insulators and motor insulators were studied by means of artificial aging caused by mechanical and thermal stresses. The artificially aged insulators were subjected to combined mechanical and electrical stresses, shock tests, puncture tests under oil, and loss angle measurements were made. The results indicated on the porcelain investigated that there was no change in the electrical and mechanical properties of porcelain in the course of time. The changes observed in cemented insulators were ascribed to the action of the cement. J.T.L., JR.

Preventing hairlines in pottery. K. GREINER. *Ceram. Ind.*, **7** [5], 556 (1926).—A description of a test carried out with 2 kilns of the same size. One kiln had smaller flues than the other. As the flues of the kiln with faulty ware had an inside diameter about 20% less than the other kiln, it was proved that the combustion gases were not carried away fast enough in the lower part of the kiln and this caused hairlines. Too small a stack is also unfavorable. F.P.H.

European porcelain industries show variance in their product. W. VERSHOFEN. *Ceram. Ind.*, **7** [5], 560 (1926).—A comparison of German, English, French, Amer., and Jap. porcelain as to composition and methods of manufacture. F.P.H.

Simplified practice division eliminates 87% of varieties of vitreous china plumbing fixtures. ANON. *Ceram. Ind.*, **7** [5], 465 (1926). F.P.H.

Selection of porcelain for electrical purposes. H. M. KRANER. *Elec. Jour.*, **23** [7], 344–48 (1926).—Data are given which show that by the proper use of American clays the kiln and drying losses can be made less than when foreign clays are used. The use of the microscope as an aid in studying the quality of porcelain is stressed. Several interesting photomicrographs are given. The appearance of the fracture is not always a safe criterion for the judgment of porcelain quality as it does not necessarily indicate fineness of grinding, degree of vitrification, or content of feldspar. Porcelain having a distinctly glassy fracture may have been produced by excessive firing, high feldspar content or finely ground normally-fired materials. The latter seems most desirable for porcelain of clay-quartz-feldspar type as they develop maximum mechanical and di-electrical strength with just enough fire to vitrify them. Photomicrographs show greater differences in the preparation of bodies than do the analyses. Most of the manufacturers give their quartz and feldspar the same preparation and thus the size of the residual quartz is indicative of the size of the feldspar grains. The former appear as anisotropic grains and the latter as glass which is isotropic. Albany slip has its advantages as an indicator of firing difference of the glaze not detectable by electrical or mechanical tests. It is not, however, an indicator of the firing treatment that the body has received. F.P.H.

A contribution to the better knowledge of high tension porcelain. K. H. REICHAU. *La Ceramique et la Verrerie*, March, 1926.—The most common complaints against electrical porcelain refer to the porosity, that is to say, to insufficient density of the porcelain body. The first property which must be required from porcelain materials which is suitable for manufacturing insulators, is therefore, that it should be absolutely dense, well glazed and fracture neither in a granular manner nor in a manner similar to sandstone. It should be able to withstand temperature changes over a long period. The thin section should not show individual isolated clusters of mullite (which can be easily produced), and at the same time many splintery fragments and much free silica. It should show a thick felted network of mullite crystals embedded in a homogeneous glassy groundmass with either no free silica or, if for any reason the presence of free silica is essential, only traces of silica grains having completely rounded edges due to the solvent action of the feldspar. Optical methods form the safest guide for the examination and evaluation of porcelain. An approximate estimation of the value of porcelain may be formed by the study of the action of hydrofluoric acid on the porcelain. The mullite crystals resist the reaction of this acid to a greater extent than does the glass of the porcelain body. The porcelain should possess sufficient mechanical and di-electrical strength. F.P.H.

Study pottery industry. ANON. *Nat. Glass Budget*, **42** [25], 11 (1926); (partial reprint from Bur. of Labor Statistics, *Bull.*, No. 412).—Statistics on a study of hours, wages, etc., in the tableware producing potteries are presented. E.J.V.

Dining-car chinaware. ANON. Bur. of Stand., *Simplified Practice Recommendation*, No. 39 (1926).—A list of recognized types and shapes of dining-car chinaware accepted by a joint conference of representatives of manufacturers, distributors, and users thereof. E.J.V.

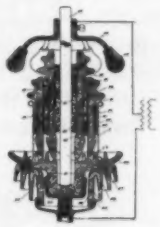
Pottery. R. L. JACK. S. A. Geol. Surv. *Bull.* No. 12, 1926.—Clay and cement in S. Australia white ware has been made by several potteries, but, there is no commercial production of high-grade wares. At least one clay is known to exist in the State that is eminently suitable for the purpose, but its inaccessibility renders it too expensive at the present time for commercial profit. O.P.R.O.

PATENTS

Production and composition of porcelain. F. M. EKERT. U. S. 1,604,395, Oct. 26, 1926. The process of producing a difficultly fusible porcelain comprising mixing clay, silica, and a flux consisting essentially of aluminum fluosilicate, and forming to desired shape, drying, and firing.

Automatic ware-making machine. FRANK W. MCDONALD AND DEMPSEY L. REEHL. U. S. 1,605,847, Nov. 2, 1926. In an apparatus for making ware, the combination with a die and means for forcing a desired material therethrough, of means for making a bat from the material forced through the die, a mold, means for transferring the bat to the mold, and means for operating on the bat to form the same into ware.

Bushing-insulator terminal. A. O. AUSTIN. U. S. 1,607,424, Nov. 16, 1926. In a dielectric bushing having a conductor extending therethrough, a fitting for the bushing having a seat therein for supporting the end of said conductor, a conductor lead, and a clamping nut having oppositely directed threaded engagement with the fitting and lead for pressing the lead into contact with the conductor. In a dielectric bushing having a conductor extending therethrough, a fitting for the bushing, means for supporting said conductor in said fitting, a lead terminal, a nut having right and left hand threaded engagement with the fitting and terminal and a weather guard for protecting the threaded engagement.



Method and apparatus for testing insulators. A. O. AUSTIN. U. S. 1,607,425, Nov. 16, 1926. Apparatus for testing an insulator comprising a plurality of electrodes spaced from one another adjacent the surface of the insulator to be tested and means for charging the electrodes to graded potentials.

Equipment and Apparatus

Redesigned driers. HOBART M. KRANER AND A. H. FESSLER. *Jour. Amer. Ceram. Soc.*, **9** [10], 679–83 (1926).—Inefficient driers used for drying dry-press porcelain were converted into flexibly controlled, efficient driers with a minimum of expense. Changes in handling, ware routing, etc. were thus averted.

A study of sieve specifications. LEWIS V. JUDSON. Bur. Stand., *Tech. Paper*, No. 321.—An investigation made on sieves tested at the Bureau of Standards showed the desirability of changes in the specifications for the U. S. Standard Sieve Series. The tolerance in wire diameter was made very liberal as wire diameter appeared to have only a 2nd order effect in actual sieving. The relation of sieving results to other measured dimensions of sieve cloth is also discussed. The revised specifications given in Letter Circ. No. 74 are listed. E.J.V.

Wire screens: A proposed British standard table. II. O. C. ELLINGTON. *Chem. and Ind.*, **45T**, 353–54 (1926).—E. modifies his previously proposed table in the sense that the widths of apertures are now expressed in round numbers representing $\frac{1}{10000}$ in., and the screens are designated by these numbers. H.H.S.

Sifting plant. A. OGILVIE. *Chem. and Ind.*, **45**, 735–37 (1926).—The efficiency of air separators is calculated from a formula given as: per cent efficiency $= A - \left(\frac{B \times C}{D}\right) \times 100$, where A and B are the % fine and oversize, respectively, in the initial feed, and C and D the % fine and coarse in the tailings after separation. The Raymond system of air separation is described with illustrations. Extremely fine products can be obtained by it, but more power is required than do mechanical air separators. O. then discusses international standards of screen fineness, and the need of a world standard. (See also *Ceram. Abs.*, **5** [12], 414 (1926.) H.H.S.

A simple experiment with CO_2. ANON. *Power*, **64** [18], 679(1926).—A simple home made apparatus for the determination of the amount of CO_2 in flue gas is described. C.J.H.

BOOK

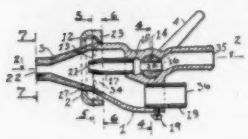
Evaporation. A. WEBER AND C. S. ROBINSON. New York. Chemical Catalog Co., 1926. Price $8.50. H.H.S.

PATENTS

Trimming machine for clay blocks. R. P. HERROLD AND T. V. H. MOORHEAD. U. S. 1,604,411, Oct. 26, 1926. A trimming machine for clay blocks, embodying a suitable trimming bed, cutters supported upon said bed, and means for successively and positively engaging the end and side edges of such clay blocks to successively move the same endwise and sidewise into engagement with the cutters.

Brick-pressing machine. FRED H. BANKERT. U. S. 1,605,201, Nov. 2, 1926. In a brick press, a frame, a press box carried thereby, plungers coöperating with the press box for pressing clots to form bricks, a bed-plate, a pusher reciprocating over the bed-plate and adapted to receive and feed clots to the press box, a trimmer blade mounted above the bed-plate and adapted to trim clots passing thereover and to drop the material removed therefrom onto the bed-plate, and means on the pusher for removing such material from the bed-plate.

Sand-blast gun. RICHARD RUEMELIN. U. S. 1,605,617, Nov. 2, 1926. The combination with a sand-blast gun, provided with a flexible hose for supplying a regulated blast of compressed air or steam thereto of a sand delivery hose, an intake device provided upon the suction end of the sand delivery hose, and comprising a tube having open ends with a series of perforations in its wall, means for closing the perforations in the wall of the tube, and a second tube surrounding the first named tube and spaced therefrom, the space between the tubes of the device being open at the upper end.



Kilns, Furnaces, Fuels, and Combustion

Gas produces better results at less cost. GEORGE D. WILKINSON. *Jour. Amer. Ceram. Soc.*, **9** [10], 693–96(1926).—A comparison of gas- and coal-fired sheet iron enamel furnaces is presented. Automatic control is possible with gas with lower amount of discount ware, fewer furnace repairs, increased production capacity, and lower operating cost. Operating cost data are given.

The Harper electric kiln. FRANCIS A. J. FITZGERALD. *Jour. Amer. Ceram. Soc.*, **9** [11], 766–72(1926).—A description of the development of an electric kiln for porcelain and of the construction of an experimental commercial unit for firing biscuit ware at the works of the Buffalo Pottery Co. The kiln is of the continuous tunnel type and in the course of its development has been used for firing porcelain at temperatures as high as 1500°C (2750°F).

Review of experimental studies on ceramic continuous kilns. BODIN. *Rev. Mat. Constr. Trav. Pub.*, **201**, 133B (1926).—A review of the work of the Syndicate Laboratory during the year 1925 on 25 kilns. The necessity of measuring the volume of gas passing through the kiln in a unit of time rather than the static pressure at the stack is mentioned. The humidity content is very important. Gas and oil fuels have also occupied their attention. N.L.

Gladding–McBean new kiln. ANON. *Brick Clay Rec.*, **68**, 798(1926).—The McDougal kiln designed for the firing of spark plugs has proved very effective for the glazing of tile. F.P.H.

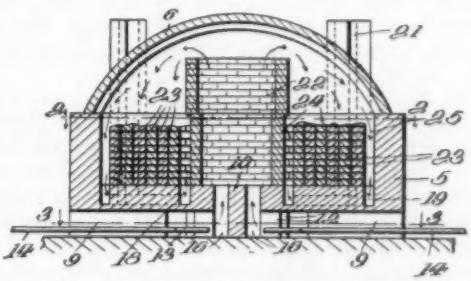
Water-smoking downdraft kilns with bituminous coal. ANTON VOGT. *Clay-Worker*, **86** [4], 295 (1926).—A description of the firing of a downdraft kiln. As long as a kiln steams green coal should not be placed on a hot fire as it will deposit soot on the damp brick. The coal should be allowed to burn nearly dead and the green coal then placed on the fire which is just hot enough to ignite it. The kiln will continue to steam preventing the black smoke which causes soot and delays the firing. An iron rod placed in the bottom peep hole through the door of the kiln will indicate whether or not the kiln is dry. F.P.H.

Tunnel kilns for firing fire brick. W. D. RICHARDSON. *Clay-Worker*, **86** [4] 296–98 (1926).—A discussion of a paper by S. R. Hind which was published in *Trans. Ceram. Soc.* (Eng.), **25**, Pt. 2 H. makes a comparison of the chamber or compartment kiln with the tunnel kiln on the following points: (1) fuel economy (2) quality of product, (3) construction and upkeep, (4) convenience of operation, (5) firing and heat control. Special requirements of a tunnel kiln for firing fire brick are discussed. F.P.H.

How much excess air? E. G. BAILEY. *Power*, **64** [16], 607 (1926).—The relation between excess air and CO_2 varies widely with different fuels; this is important where one fuel is being substituted for another, or 2 different fuels are being used simultaneously. Curves are given showing the excess air necessary for proper combustion with various fuels. C.J.H.

PATENT

Brick kiln. JOHN K. GILLAM. U. S. 1,607,525, Nov. 23, 1926. A brick kiln or the like, comprising a kiln chamber adapted to receive the brick to be fired, a tunnel beneath the chamber and extending transverse the same, a flash-wall in the tunnel and burners for directing fire against the flash-wall, passageways for the heat from the burners to pass into the kiln chamber, the brick in the kiln chamber piled to form a flue for directing the heat to the upper part of the kiln chamber, flues in the kiln chamber floor in communication with chimneys for carrying off the heat after the same has circulated through the brick, and the tunnel providing inlet means for cold air to the burners and a walk-way, whereby the burners can be reached by an operator for regulation.



Geology

Zettlitz kaolin in Czechoslovakia (C-S). O. KALLAUNER. *Rev. Mat. Constr. Trav. Pub.*, **201**, 121–7B, **202**, 145–9B, **203**, 169–173B (1926).—Two types of Zettlitz kaolin are prepared, (I*a*) Consumed by C-S 41%, Germany 51, (II*a*) C-S 18%, Germany 55, Poland 10, Switzerland 7.5. A general description of mining operations and a flow sheet for washing and purification are given. The properties of the kaolin are enumerated in great detail. Kaolin I*a* contains 91–95% kaolinite (95–99% clay substance), while II*a* contains 84% kaolinite (91% clay substance), the remainder consisting of quartz, mica, feldspar, pyrite, sulphates, carbonates, organic matter. Chemical analysis: individual analyses (18) made from 1908 to 1925 are given, as well as some older ones.

Averages	Kaolin Ia (18) %	Kaolin IIa %	Averages	Kaolin Ia (10) %	Kaolin IIa %
SiO	45.66–47.83	52.43	MgO	0.10– 0.38	0.01
Al_2O	36.83–39.10	33.26	K_2O	0.30– 1.00	——
Fe_2O_3	0.43– 1.01	1.93	Na_2O	0.27– 0.70	——
TiO_2	0.36– 0.50	0.54	Ign. loss	12.00–14.16	10.08
CaO	0.08– 0.78	0.24			

About 0.026–0.037% of kaolin is dissolved in water. Solubilities in HCl, HNO_3, H_2SO_4, acetic, and formic acids at 15 and 100°C are given, as well as solubility in NaOH and Na_2CO_3 for various concentrations and periods of time. Densities: Dry, 2.63, fired to 800°C 2.53, 1000° 2.68, 1200° 2.71, 1315° 2.67. Av. dimension: 4.8μ; max. dimension 7μ, 6.6 x 10^9 grains per gm. Screen analysis: crude clay 30.6% on 64-mesh (per sq. cm.), 49.5% on 225-, 57.2% on 900-, 61.2% on 4900-, 62.2% on 10,000-. Dry (washed) kaolin: Ia 0.02% on 900-, 1.2% on 4900-, 3.44% on 10,000-. Absorption of water in presence of 10% H_2SO_4, 3.85–5.88%. Water for normal working 42–54% by weight of clay. Plasticity values determined by numerous methods given. Reactions to heat: Thermal changes on heating, exothermic and endothermic reactions common to clays. Briefly the transitions are given as the anhydride $Al_2Si_2O_7$ stable after dehydration up to 750°C, above that the separation of SiO_2. Above 900° the transformation into dumortierite ($Al_5Si_3O_{18}$). At 1030° the latter is transformed into sillimanite and at 1100° into sillimanite and SiO_2. (Sillimanite is given as $Al_2O_3 \cdot SiO_2$ the composition for the natural mineral. No mention is made of mullite. Abstr.), Fusion point: Kaolin Ia, Seger cone 35–36; kaolin IIa, cone 32. Water absorption after firing to various temperatures from 500 to 1435°C. Several other properties are given. Bibliography: The article ends with a long bibliography taken from at least 18 periodicals, grouping the papers for each year separately, from 1906 to 1925; besides giving a list of references for general literature on the subject taken from books.

L.N.

Manganese and bauxite in India. S. B. Banerjea. *Eng. Min. Jour.-Press*, **122,** [7], 254 (1926).—Manganese is the leading mineral exported from India, but since the war the demand for manganese has gone down due, more or less, to the stocks in the United Kingdom, Japan, and the U. S. being excessive. Also, the cessation of orders is most likely due to the high prices for manganese ore which are being charged by the sellers. Rough Indian ore shows on analysis: 46.8% metallic manganese, 5.60% iron, 2.00% silicon, and .007% phosphorous. Good ore contains as much as 55% metallic manganese. Only 1 or 2 of India's several vast deposits of bauxite are being worked. India can fully meet at least half of the world's requirements of bauxite. The drawback is that the freight and mining and shipping costs are so great that there is no margin or profit left. In France, cement manufacturers use bauxite in the manufacture of aluminous cement. If the Indian railways would reduce their freight rate considerably and other charges be reduced then a profitable trade with France and the U. S. could be set up.

A.H.K.

Grinding feldspar in Tennessee. D. F. Farrar. *Eng. Min. Jour.-Press*, **122,** [18], 692–94 (1926).—One principal source of supply of potash feldspar is in Tenn. along the western border of N. Car. The mineral occurs in great quantities in a pegmatite dike. It is mostly hand-picked when loaded in railroad cars for shipment about 50 miles to Erwin, Tenn. At Erwin there are 3 grinding plants and at Bristol, Tenn. there is 1. These 4 grinding plants produce about $\frac{1}{3}$ of the total production of the U. S. A typical analysis of a sample from these plants is: silica, 65.10%; alumina, 20.38%; potash,

11.16%; soda, 1.10%; lime, 1.96%. This is very close to the theoretical composition of pure orthoclase and shows that the hand picking of the lump rock, to free from quartz and other impurities, is well done. The same general method of procedure in grinding is used at all 4 plants; namely, jaw-crushers for preliminary crushing; then Hardinge mills which were in some cases followed by tube mills. All grinding is conducted dry. Ground feldspar is supplied to the trade in 3 degrees of fineness, 80- to 100-mesh, 140-mesh and 200-mesh. The glass manufacturers use the coarser size; 140-mesh is used in enamels and the pottery trade requires the 200-mesh size. The average capacity output of ground feldspar per plant is from 1500 to 3600 T. per month.

A.H.K.

Applied geophysics. G. TUCHEL. *Can. Min. Jour.*, **47,** 1058 (1926).—Geophysical methods are of value in reducing drilling costs, and in enabling one to drop leases or concessions without wasting money for useless work. There are 4 methods of application. (1) The measurement of gravitation, (2) the magnetic method, (3) the seismic and acoustic method, based upon the elasticity of various formations, (4) electric, depending on the conductivity of formations. The 4th method is applicable chiefly to metalliferous ore bodies. H.H.S.

Clays of Lake Agassis Basin (Canada). J. E. MAYNARD. *Trans. Roy. Soc. Can.*, 103–114, Sec. 4 (1925).—The high total percentage of fluxing ingredients in the clay limits it technically to the manufacture of common brick, sewer pipe, and drain tile. Temperatures from 200°C upward gradually destroy the colloids in the clay, and at approximately 1000°C the colloids are completely destroyed. This gradual destruction may have taken place either by an aggregation of the colloid particles to form particles above the colloid size or by the colloids becoming irreversible. The Lake Agassis clays have an exceptionally high percentage of coarse and fine clay. The fineness of grain of both the fine and coarse clays increases with depth, and since the hygroscopicity also increases with depth, hygroscopicity would appear to give a relative measurement of the grain of the clay. O.P.R.O.

Mining bentonite in California. J. MELHASE. *Eng. Min. Jour.-Press*, **121,** 837–42 (1926).—Analyses of "otaylite" and "amangosite" yield, respectively, the formulas $MgO \cdot Al_2O_3 \cdot 5SiO_2 \cdot 8H_2O$ and $MgO \cdot Al_2O_3 \cdot 5SiO_2 \cdot 7H_2O$. Alkali waters containing Na_2SO_4, Na_2CO_3, NaCl, $Na_4B_2O_7$ and $CaSO_4 2H_2O$ caused the alteration of volcanic ash to form bentonite. (*C. A.*)

Chemistry and Physics

Electro"smosis and its application to the purification of clays and kaolins. GRANGER. *Rev. Mat. Constr. Trav. Pub.*, **201,** 135B (1926).—To 10 tons of ground clay in slip form 10 liters of solution of sodium silicate (d. 1.33) are added before the slip enters the osmose machine. The machine consists of a tank in which a horizontal cylinder forming the positive pole revolves, the tank with a concentric shell forms the negative pole. An osmose machine with a cylinder 60 cm. in diameter produces 6 tons of kaolin in 24 hrs. and consumes 17.5 KW of electricity at 110 volts. Changes in composition due to treatment are as follows:

Clay	Fusion in cones		% Al_2O_3	
	Before treatment	After	Before treatment	After
Bohemian	27	32–33	20	38
English	28–29	33	29	39
Hungarian	26	32	20	38

The increase in cost appears to be the only objection. Iron in the form of silicates is eliminated from the clay but iron in the form of the carbonate or hydrate remains in

the clay, being carried to the anode. Fine sand not removed by washing is also removed by the process. L.N.

The properties and testing of ceramic finished products. III. Thermal measurements. SCHEEL. *Ceramist*, **8** [7], 451–65 (1926); (Trans. by W. L. Shearer and A. W. Holzmann).—The thermal properties of ceramic products often determine their use and are of great importance. (1) The fusibility can be found according to the usual methods used with refractories. (2) The coefficient of expansion is defined and the comparison, tube, and interferometer methods of measurements described. Tables showing the coefficient of expansion of porcelains and a number of other ceramic materials are given. The expansion of quartz and of quartz glass is described more fully. (3) The specific heat of a body is defined and the mixing, ice calorimeter, and electric methods of measurement described. An extensive table giving the specific heats of a large number of materials at different temperatures is given. (4) The Winklemann and Schott formula for the coefficient of thermal endurance is given and discussed. The need for research to determine to what extent it is applicable to partially sintered ceramic products is pointed out. A.E.R.W.

Tentative methods of chemical analysis of limestone, quicklime, and hydrated lime. *A. S. T. M. Tent. Stand.*, 290–303 (1926), Ser. Designation, C 25–26 T.—Treatment of sample is described followed by a description of methods for the determination of silica and insoluble matter including silica, total iron and aluminum, total iron, total aluminum, calcium (gravimetric and volumetric methods), strontium, magnesium, volatile matter, mechanical moisture, carbon monoxide, sulphuric anhydride, total sulphur, phosphorus, manganese, ferrous iron soluble in sulphuric acid (in either presence or absence of carbonaceous matter). The determination of available lime in quicklime and hydrated lime by the modified Scaife method is also given. Preparation of standard solution of potassium permanganate is described. A long list of notes is given together with a form for reporting the analysis. R.A.H.

Uses of fluorspar. HERBERT W. DAVIS. *Amer. Glass Rev.*, **46** [7], 14 (1926); *Nat. Glass Budget*, **42** [29], 6 (1926); (Partial reprint from Bur. of Mines Rept.).—Physical and chemical properties of fluorspar are listed. Its use in the manufacture of ceramic products and specifications it must meet for this purpose are discussed. From 80 to 85% of the fluorspar produced in the U. S. is used in basic open hearth steel furnaces as a flux. E.J.V.

What is light? MICHAEL L. PUPIN. *Nat. Glass Budget*, **42** [27], 21 (1925); (reprinted from *N. Y. Times*.).—An explanation of the phenomenon of light from the standpoint of physics is given. E.J.V.

Measurement of high temperature and the improved electric filament pyrometer. FOERSTER. *Feuerungstech.*, **14** [24], 285 (1926).—A general description of physical principles followed in temperature measurements and apparatus used up to temperature of 1900°C followed by a detailed description of the Siemens (improved Holborn-Kurlbaum) electric filament pyrometer for measurements of 4000°C and over. F.A.W.

Manufacturing phosphate by the calcining process. G. R. BROBST. *Cement Eng. News*, **29** [19], 49 (1926).—A more stable form of phosphate can be made economically by calcining rock to a clinker. L.A.P.

The heat capacity of calcium silicate. GEO. S. PARKS AND K. K. KELLEY. *Jour. Phys. Chem.*, **30** [9], 1175–78 (1926).—Work of White continued by P. and K. giving complete data as to heat capacity at constant pressure, Cp, per gram atom of pseudowollastonite from 88.2° to 1573° absolute. Cp increases from 1.52 at liquid air temperature to 6.33 at 1573° absolute. Above 200° absolute, the sum of the molecular heat capacities of CaO and SiO_2, determined separately, agrees well with the experi-

mentally determined and calculated values of the molecular Cp of $CaSiO_3$. Above 300° absolute the same applies to the sum of the Cp values of MgO and of SiO_2 as compared to the experimentally determined and calculated values of Cp for $MgSiO_3$. Except at lowest temperatures the Cp of a simple silicate can be accurately estimated from the known Cp values of the component oxides. L.A.P.

The effect of hydrogen-ion concentration on the viscosity of the hydrosols of Al_2O_3, Fe_2O_3 and Cr_2O_3. JOHN H. YOE AND E. B. FREYER. *Jour. Phys. Chem.*, **30** [10], 1389–1400 (1926).—The effect of variations in *p*H upon the viscosity of these hydrosols was measured at 25°C with an Ostwald viscometer, *p*H range extending from 2.5 to 9. The sols contained from .03 to .015 % of the respective oxides. No change in viscosity was noticed in any case as *p*H increased from 2.5 to about 6.5. At *p*H 7, the "critical" H^+ concentration, the viscosity began to increase rapidly to a maximum and then dropped fairly rapidly to a nearly constant value. The *p*H at maximum viscosity varied with the different sols and their concentrations, range being 7 to 8.4. More concentrated Fe_2O_3 sols (.85 and .12 %) showed a slight decrease in viscosity with small additions of NH_4OH, but further additions caused an increase, at first very slight, then rapidly to a maximum, then finally dropping fairly rapidly to an approximate constant value. It is suggested that changes in viscosity of the sols is in part due to changes in degree of hydration. The water may be partly combined chemically, partly adsorbed and partly occluded. L.A.P.

Potentiometric titration of tin with potassium bromate. K. SANDVED. *Chem. and Ind.*, **45**, 757 (1926); Meeting Oct. 6, Soc. Publ. Analysts.—Stannous tin is oxidized by $SbCl_5$ or $FeCl_3$ and the reduction compound titrated potentiometrically with $KBrO_3$. A method of determining Sn in presence of Sb has been devised, and the potentiometer titration of ferrous iron has been closely studied. H.H.S.

Sixth Congress of French Industrial Chemistry. W. CULLEN. *Chem. and Ind.*, **45**, 758 (1926).—Held at Brussels Sept. 26–Oct. 2, as the constitution of the Society makes provision for the holding of the Congress outside France, but in French-speaking countries. Delegates were from most European nations and from Japan. H.H.S.

Institution of chemical engineers. ANON. *Chem. and Ind.*, **45**, 761 (1926).—By invitation of the A. I. C. E., a joint meeting of Brit. and Amer. chemical engineers will be held in the U. S. in 1927 or 1928. The first examination for associate membership of the Institution has been held. H.H.S.

A surface-tensiometer and an osmometer for class work. F. E. LLOYD AND G. W. SCARTH. *Science*, **64**, 253–54 (1926).—Inexpensive apparatus are described using the ring method with a chainomatic balance to measure surface tension, and tubes provided with a $Cu_2Fe(CN)_6$ (in gelatin) membrane to measure osmotic pressure. (*C. A.*)

Methods of physico-chemical research at high temperatures. F. M. JAEGER. *Bull. Soc. Chim. Belg.*, **35**, 213–29 (1926).—A lecture describing methods of conductivity determinations, surface tension measurement, etc., at high temperatures. (*C. A.*)

A study of the vitreous state through enforced crystallization. I. F. PONOMAREV. *Z. anorg. allgem., Chem.* **155**, 281–90 (1926).—Glass subjected to very slow cooling crystallizes in hexagonal prisms. The temperature and velocity of crystallization were determined for various glasses. (*C. A.*)

The volatility and dissociation of borax. H. V. A. BRISCOE AND P. L. ROBINSON. *Nature*, **118**, 374 (1926).—Contrary to Kolthoff's observations, evidence is presented to show that fused borax loses NaO. (*C. A.*)

The oxides of chromium. ARTHUR SIMON AND THEODOR SCHMIDT. *Z. anorg. allgem. Chem.*, **153**, 191–218 (1926).—A study of the relative stabilities of the oxides of Cr by an examination of the decomposition diagrams at constant pressure. When

CrO_3 is heated, it passes to Cr_5O_{12} from 260 to 285°, thence to Cr_5O_{12} from 360 to 366° and thence to Cr_2O_3 at 410°. The 2 intermediate oxides are shown to be chromic chromates and decompose as follows: Higher oxide → lower oxide+CrO_3; CrO_3 → lower oxide+O_2. CrO_2 and Cr_5O_{18} are both less stable than Cr_5O_{12} and hence cannot be prepared by heating Cr_5O_{12}. This explains why they do not occur in the above series. The magnetic oxide, Cr_3O_8, was examined by its decomposition curve and found to be more stable than Cr_5O_{12}. In all cases the solid phases were identified or confirmed by Debye X-ray photographs. (*C. A.*)

Physical properties of ceramic bodies. F. SINGER. *Z. Elektrochem.*, **32**, 382–95 (1926).—Ceramic products are arranged according to their common nomenclature in 7 groups. Considered solely from the point of view of chemical composition, these groups are shown to vary from 2-component to multi-component systems. All the 3- and 4-component systems are based on the 2-component system $\cdot Al_2O_3 \cdot SiO_2$; *e.g.*, in combination with alkalis as porcelain and earthenware; with alkalis and lime as earthenware; and with alkalis and iron oxide as stoneware. Unlike fusions, sintered ceramic bodies are characterized by incomplete physical and chemical homogeneity in the liquid phase; they contain, in addition to a fused glassy matrix, undissolved crystallites of raw material and newly-formed crystals. The latter determine the characteristics of the product. The results of mechanical and thermal tests on the various types of ceramic products are given in tables. Photomicrographs are reproduced to illustrate the importance of the effect of mullite crystals, their arrangement and distribution, upon the physical properties of ceramic bodies. The modern aim is to produce the maximum number of minute mullite crystals in close, felty formation embedded in a homogeneous glass. (*Brit.C.A.*)

Fining of pure and aluminous alkali-lime-silicate glasses with saltcake or arsenic. E. ZSCHIMMER, E. ZIMPELMANN, AND L. RIEDEL. *Sprech.*, **59**, 331–33, 353–57, 393–95, 411–13, 422–25 (1926).—The effect on the melting of the glass SiO_2 74%, CaO 13%, Na_2O 13%, and on glasses derived therefrom by the replacement of silica by 1 to 12% of alumina, of additions of saltcake (with or without niter), and arsenic with niter were observed. The simple soda-lime glass was fined best by addition of 0.2% Na_2O as sulphate. With increase of alumina tendency to foaming increased. With 0.2% of soda as sulphate the parent glass was best fined according to the time-temperature scheme (after the last filling on): 1350–1480° (1 hr.), 1280° (2 hrs.), when 100 g. of glass were melted. During the period of rise of temperature the saltcake reacted with silica, and the SO_3 so formed serving as resistance. In the apparatus of Schultz the charcoal is raised to the necessary temperature by resistances separated from the charcoal; by this means fluctuations in current are avoided, the electrical connections are not attacked by the gases, and the whole body of the charcoal is uniformly heated. The retort measures 2 by 3 m. and is $2\frac{1}{4}$ m. high for an output of 500–700 kg. of carbon disulphide, while the consumption of power is 30 kw. for 1000 kg. of carbon disulphide, the efficiency being 75–80%. This furnace is more under control than the older types, working costs are lower, and the heating efficiency is higher. (*Brit.C.A.*)

BOOKS

Hydrogen-ion Concentration. L. MICHAELIS. Trans. by W. A. Perlzweig. Baltimore: Williams & Wilkins Co. Price $5.00. H.H.S.

Practical Colloid Chemistry. W. OSTWALD, P. WOLSKI, AND A. KUHN. (Trans. by J. N. Kuggelmass and T. K. Cleveland). London: Methuen & Co., 1926. Price 7*s* 6*d*. H.H.S.

General

Characteristics of pyrometric cones. C. O. FAIRCHILD AND M. F. PETERS. *Jour. Amer. Ceram. Soc.*, 9 [11], 701–43 (1926).—For the first time the characteristics of pyrometer cones have been determined under definite and reproducible conditions of heating. The temperatures of the "end points" of a complete set of cones together with their bending intervals were measured at carefully controlled rates of heating in clean air and in various kiln gases. Heated at 20°C per hour in furnace gases free from SO_2, the end points of cones 015 to 01 are somewhat higher than those observed when the cones were heated in clean air. Cones 022 to 016 and 1 to 42 were acted upon only slightly by kiln gases free from SO_2. There is more significance in the demonstration of the utility of measuring the end points of the cones under accurately controlled and known conditions of heating than in the numerical results obtained.

A comparison of the softening points of some foreign and American pyrometric cones. R. F. GELLER AND E. E. PRESSLER. *Jour. Amer. Ceram. Soc.*, 9 [11], 744–57 (1926).—This paper is a report of results obtained from a study of the softening points of pyrometric cones as made in England, France, Germany, and America. The results are briefly discussed and are also shown photographically so that interested readers can best obtain the specific information they desire from a study of these photographs. The data obtained further indicate that the temperature at which the cones most used in the trade (Nos. 1 to 20) soften can be determined with an accuracy of ±15°C in laboratory kilns of the gas-fired type, provided good pyrometric equipment is used and reasonable precautions are taken to maintain definite rates of heating. Errors of as much as ±25° can be expected in the determination of temperatures at which cones less refractory than No. 1 or more refractory than No. 20 soften. In the case of more refractory cones this is due principally to the difficulty of maintaining definite rates of heating while, in the case of the less refractory cones Nos. 022 to 01 inclusive, inaccuracies can be attributed both to difficulty of maintaining definite heating rates and to the sensitiveness of the softening behavior of the cones to furnace atmospheres. This is particularly true of the "red series" (cones 010 to 01) the softening points of which are materially affected by changes of a few per cent in the CO_2 and SO_2 content of furnace gases.

Report of the Czechoslovakian (C–S) Ceramic Society at the International Congress of Chemistry held at Bucharest, June 20–26, 1925. RUDOLPH BARTA. *Rev. Mat. Constr. Trav. Pub.*, **201**,141–43B, (1926).—(1) Introduction of Zettlitz kaolin as a standard. The suggestion that Zettlitz kaolin be recognized as a standard has been accepted by the Congress. The C–S Ceram. Soc. has organized a service bureau, and a subcomm. at Carlsbad has set aside a quantity of normal kaolin for the purpose. Samples will be sent gratuitously to each country for scien. work. (2) Rational analysis of clays and of ceramic materials. The C–S Ceram. Soc. proposes to introduce to the International Comm. for consideration the method of analyses of O. Kallauner and J. Matejka. (The method is given in some detail, but the connection between results and calculations from them is not clear. [Abstr.]). (3) Testing of raw material samples in the ceram labs. in C-S. (4) International ceramic nomenclature. Since each language today has a series of expressions which cannot be exactly translated into another language the C-S Ceram. Soc. proposes a formula to characterize exactly all ceramic materials. For example $\frac{0.15\ p\ 34\ S}{Cer\ 38\ Al_2O_3\ 100/1350\ P}$ would mean a refractory brick having 15 % proosity, a refractoriness of Seger cone 34, an alumina content of 38 %, and a resistance of 100 kg. per sq. cm. at 1350° C. L.N.

When you design a new product. L. T. PARKER. *Brick Clay Rec.*, **69** [9], 661 (1926). —The writer defines a design patent and discusses the matter of infringement of this type of patent. The law is that an article must be new and ornamental to be the subject of a valid design patent. Even though a patent is valid a suit for infringement may not be decided in favor of the patentee, if the 2 designs in litigation are not so alike in appearance as to appear identical to the eyes of an ordinary observer. It is not proper to seek the advice of expert witnesses as to whether or not infringement exists in this type of patent. F.P.H.

Developing new processes. L. T. PARKER. *Brick Clay Rec.*, **69** [10], 745 (1926).—A few pointers on the process patent and the composition patent. F.P.H.

Examples of plant arrangements in the industry. ANON. *Ceram. Ind.*, **7** [5], 562–64 (1926).—General plant layouts of some ceramic plants are given along with flow sheets for the processes employed. F.P.H.

Raw materials used in the production of ceramic wares. ANON. *Ceram. Ind.*, **7** [5], 473–554 (1926).—The properties, composition, and uses of materials used in ceramic production are given. The materials are listed alphabetically. A number of errors has escaped the attention of the editors. F.P.H.

The electrical precipitation of smoke and fume. H. W. C. HENDERSON. *Chem. and Ind.*, **45,** 834 (1926).—Describes the Lodge-Cottrell process, of which the features claimed as predominant are: (1) The gases have an unrestricted gas passage throughout the apparatus, thus causing no back-pressure; (2) No preliminary gas cooling is required: gases can be treated at any temperature between atmospheric and 1400°F; (3) Power consumption and maintenance costs are almost negligible, while the labor and attention required for even a large installation are very small. H.H.S.

The calculation and measurement of air flows in mines. J. L. HODGSON. *Engineering*, **122,** 58–59, 122 (1926). H.H.S.

The care and custody of books. F. W. CLIFFORD. *Chem. and Ind.*, **45,** 793–95 (1926).—The librarian of the English Chem. Soc. writes on the formation of research libraries, and stresses the high standard of Ger. and Amer. factories in this particular. H.H.S.

Technical literature. ANON. *Chem. and Ind.*, **45,** 790–96, 802 (1926).—A semi-annual review of new and forthcoming books. H.H.S.

A new study of grinding efficiency and its relation to flotation practice. E. H. ROSE. *Eng. Min. Jour.*, **122,** 331–38 (1926).—A so-called "grinding index" is derived by using 200-mesh size as a 100% basis, 1.5 in. round 0.18%, 0.5 in. 0.46%, 20-mesh 7.36%, 100-mesh 41.43%, etc. R. discusses the means of deriving this index and offers proof of its applicability to practice. (*C. A.*)

Ceramic products. Report of the Belgian National Chemical Committee. LECRENIER. *Compt. rend. 6e conférence intern. chim.* (*Bucarest*) **1925,** 373–76.—Description of the methods used in Belgium for the determination of H_2O, loss on ignition, SiO_2, $Fe_2O_3+Al_2O_3$, CaO, MgO, alkalis, Fe_2O_3, and for carrying out the "rational" analysis (free SiO_2 feldspar). The latter is not used to any great extent in the examination of ceramic clays in Belgium. **Report of the Fédération Nationale des Associations de Chimie de France.** A. GRANGER. *Ibid.*, 377–78.—"Rational" analysis gives reliable results only when the sample consists exclusively of a mixture of kaolinite and quartz sand; in other cases it is of some value if the results are interpreted with due regard for other minerals present. **Report of the National Research Council of Japan.** TOYOKICHI TAKAMATSU. *Ibid.*, 378–84.—Detailed description of the technic generally

used in Japan for the determination of H_2O loss on ignition, SiO_2, $Fe_2O_3+Al_2O_3$, TiO_2, CaO, MgO, alkalis, quartz, and feldspar. **Report of the Chemische Raad van Nederland and of the Nederlandsche Vereeniging van Aardewerk Fabrikanten.** H. D. MAUSER. *Ibid.*, 384–87.—The methods used in Holland are those of Hillebrand, of Bollenbach, or method C18–21 of the A.S.T.M., with minor variations in technic. The value of the determination of quartz and feldspar, which is not used to a great extent in Holland, would be increased by standardizing the technic. **Report of the Fédération Nationale de Chimie pure et Appliquée de Polognée.** J. ZAWADZKI. *Ibid.*, 387–89.—Outline of the standards and tests for Portland cement and of the tests of ceramic clays, used in Poland. **Report of the Société Chimique de Roumanie.** GEORGES CAPSA. *Ibid.*, 389–96.—"Rational" analysis of clays is of considerable value in the control of ceramic mixtures. The error introduced by considering foreign minerals as feldspar and sand are of no importance in ordinary ceramic mixtures. C. describes in detail the technic he has followed for 15 years. It differs from the usual procedure chiefly in that the solutions are filtered instead of decanted after treatment with HCl and with NaOH, thereby greatly increasing accuracy and speed. C. shows that from the complete chemical analysis of the original clay and the complete chemical analysis of the insoluble residue remaining after treatment with H_2SO_4 the nature and proportion of the various minerals present can be calculated. Taking as an example the Ledetz kaolin which Seger (Seger's gesammelte Schrifte, 1896 edit., p. 44) gives as consisting of kaolinite 86.27, feldspar 8.65, sand 5.08%, C. shows that it consists of: kaolinite 85.89, $MgCO_3$ 0.38, muscovite mica 5.04, orthoclase feldspar 3.51, shale 1.41, sand 4.16%. **Report of the Société Céramique Tchécoslovaque.** BARTA. *Ibid.*, 396–98.—The Society proposes using the Sedlice (near Karlovy Vary) kaolin as standard and has prepared 100 kg. to be distributed as standard samples. O. Kallauner's and J. Matejka's method for the determination of the mineral constituents is proposed as standard. The method is based on the determination of $CaCO_3+MgCO_3$ by treating with cold 1:1 HCl for 15 min., determination of loss on heating 30 min. at 950–1000°, of loss on heating 1 hr. in an electric furnace at 650–700°, treatment of the residue from the latter heating for 3 hrs. in the water bath with HCl (d 1.1), nad determination of Al_2O_3 and Fe_2O_3 in solution and in the undissolved residue. If an appreciable amount of mica is present, alkalis should be determined both in the portion dissolved out by HCl and in the original sample. The method of calculation is not clear from the article. (*C. A.*)

Production from raw clay of material stable towards water. P. P. BUDNIKOV. *Kolloid-Z.*, **39**, 269–75 (1926).—With the object of producing a cheap building material experiments have been carried out on the stabilizing action towards water of various substances on raw clay. The addition of alkalis up to about 5% increases the susceptibility to attack by water, larger additions make the clay immune, while with still larger quantities the clay is again attacked by water. Phosphoric acid (3–6%), free or in the form of a mixture of tricalcium phosphate, superphosphate, or phosphorite and sulphuric acid, renders the clay quite resistant to attack. It also reduces the shrinkage on drying, particularly if 10% of asbestos be added. It has no marked effect on the tensile strength except when added as calcium phosphate and sulphuric acid, when it increases it by 50%. Unfortunately, the action of phosphoric acid depends on the composition of the clay; *e.g.*, in a series of clays having a silica content ranging from 5.5 to 42.5%, only those with 27.0% and under were stabilized completely by the above amount, *viz.*, 3–6%. Experiments designed to explain the action of phosphoric acid were inconclusive. It probably depends on the colloidal nature of the clay and the coagulative action of the acid. (*Brit. C. A.*)

Deformation of ceramic masses on drying. O. KRAUSE. *Kolloid-Z.*, **39**, 263–64 (1926).—Ceramic masses of high plasticity, especially those rich in kaolinite, show on

drying a twisting in a direction opposite to that in which they were worked on the potter's wheel. In some cases this torsion manifests itself by the formation of characteristic cracks during firing. (*Brit. C. A.*)

Drying of ceramic ware. W. PUKALL. *Sprech.*, **59**, 367–70 (1926); *Chem. Zentr.*, **2**, 1317 (1926).—Moisture can be raised from a depth of 9.5 m. by simple evaporation at the porous surface of a P. filter. In fine-pored materials only capillarity comes into play on drying, and this goes on only at the outer surface. In large-grained masses the drying may also occur from the surface toward the interior. The rate of drying of fine-pored and fine-grained materials is consequent upon external atmospheric pressure and such materials are dry within while still moist at the surface. The drying process is independent of atmospheric pressure. Cooling and a reduced internal pressure results from the evaporation of the water. Drying is dependent upon the temperature and humidity of the air. The boiling point of the internal water, under negative pressure, need not be exceeded by the application of artificial heat. The most suitable condition is that in which the vapor pressure within the material approaches that holding externally. Drying goes only so far that internal and external air pressures are equal. Dryness can be attained by means of porous materials capable of absorbing moisture as well as by the air. (*Brit. C. A.*)

Book Reviews

Feldspar. OLAF ANDERSEN. Norwegian Geol. Surv., *Bull.*, No. 128A.—The present publication is a description, in non-technical language, of the properties, geological mode of occurrence, exploitation, and uses of feldspar with special reference to the Norwegian feldspar industry. Systematic descriptions of commercial deposits are reserved for a future publication to be issued as No. 128B of the present series.

Chapter I contains a general description of the mineralogical, chemical, and physical properties of the various species of the feldspar group. Table I gives the theoretical chemical compositions of mixtures of potash feldspar and soda feldspar for intervals of 10% by weight. Table II gives the corresponding figures for mixtures of soda feldspar and lime feldspar. Table III contains a few examples of chemical analyses of feldspar from Norwegian occurrences. The analyses, of which Nos. 1–5 are new, represent selected, "pure" feldspar. Nos. 1, 2, and 3 are commercial "potash feldspars" from granite pegmatites, No. 4 a soda-potash feldspar from syenite pegmatite, and No. 5 a soda feldspar of commercial quality from a pyroxene bearing granite pegmatite. Nos. 6 and 7 are old analyses respectively of oligoclase from granite pegmatite and labradorite from anorthosite. Table IV contains multiplication factors from the recalculation of feldspar analyses; Tables V, VI and VII are examples of such calculations.

In the section headed "3 Smelting" the thermal properties of the feldspar minerals are described somewhat in detail. Figure 7 is a melting diagram for potash-soda feldspars. Curve 1 represents the temperatures of incipient melting (according to unpublished observations of the writer), and curve II the softening temperatures (according to data published by Watts). Fig. 8 is the melting diagram for lime-soda feldspars (after Bowen). Table VIII gives a synopsis of the properties of the common species of feldspar.

The various species are briefly described in a separate section. The structural features of perthites are illustrated by the microphotographs reproduced on Figs. 16–24. Each specimen is represented by two photographs, one, marked *A*, of a section parallel to the first cleavage and another one, marked *B*, of a section parallel to the second cleavage. All photographs have the same magnification (the scale is given on Pl. IV). In the *A*-sections the crystallographic *b*-axis is vertical and in the *B*-sections, horizontal. The potash feldspar of the perthite is always a microcline (orthoclase has not been found in granite pegmatite from Norwegian occurrences), but sometimes it is com-

posed of single individuals, thus lacking the twinning structure characteristic of most specimens of microcline when seen under the microscope. Figs. 16–20 represent perthites with ordinary cross-hatched microcline, Figs. 21–23 perthites with untwinned microcline. Fig. 24 is an anti-perthite where the host is an albite and the perthite intergrowths (dark on the photographs) are microcline

Chapter II is devoted to the composition, structure, and geology of granite pegmatites.

The following minerals are known from Norwegian occurrences of such pegmatites: actinolite, aeschynite, albite, albite-oligoclase, allanite (orthite), alvite, andesine, anthracite ("coalblende"), apatite, bertrandite, beryl, biotite, bismuth, bismuthinite, blomstrandine, bornite, calcite, chalcopyrite, chlorite, chrysoberyl, columbite, epidote, epidote-orthite, euxenite, fergusonite, fluorite, gadolinite, garnet, gold, hellandite, ilmenite, ilmenorutile, kainosite, keilhauite (yttrotitanite), lepidolite, magnetite, microcline (microcline perthite), molybdenite, molybdic ocher, monazite, mossite, muscovite, oligoclase, orangite, parisite, phenakite, polycrase, pyrite, pyrrhotite, quartz, risørite, salite, samarskite, scapolite, sulphur, tengerite, thalenite, thorite, thortveitite, titanite, topaz, tourmaline (black), tungstic ocher, uraninite (brøggerite and cleveite), uranophane, wolframite, xenotime, yttrofluorite, zeolites (a few species), zinkblende, zirkon.

The granite pegmatites of Norway are of many different types with regard to composition, structure, and geological occurrence. The main minerals are always quartz and feldspar, both potash soda feldspar (microcline perthite) and lime soda feldspar (usually oligoclase) being present in nearly all deposits, but the relative amounts of these minerals may vary within wide limits. Small amounts of pure albite are often found. Of the dark minerals biotite is most common; it is seldom entirely lacking, but sometimes scarce, accompanying the other dark minerals which may be muscovite or black tourmaline, rarely pyroxene (salite) or hornblende. Garnet is a common constituent, especially of the pegmatites rich in muscovite; magnetite is the commonest iron ore mineral and pyrite the commonest sulphide. A characteristic feature of many of these pegmatites is a comparatively frequent occurrence of various minerals containing rare earths or other unusual constituents. Thus allanite is rather common, and fergusonite and minerals of the euxenite group are found in many places. Beryl, gadolinite, thorite, and monazite occur in several localities and sometimes in considerable quantities; uraninite, columbite, and alvite are also found in a number of pegmatites. Graphic granites, of which Fig. 15 and Figs. 25–29 are illustrations, occur in most of the pegmatites here considered. Also various other intergrowths are known, *e.g.*, quartz with tourmaline, garnet, or muscovite and muscovite with garnet or epidote. Feldspar and quartz may occur in large crystals, cleavage faces of microcline perthite sometimes measuring more than 10 m. and such crystals weighing more than 100 tons. Mica (muscovite and biotite) is sometimes seen in plates 2–3 m. long and ½ m. thick. Also tourmaline, beryl, and topaz may be found in crystals of considerable size. Miarolitic cavities containing crystals of quartz, albite, muscovite and other minerals are sometimes seen; they are usually small, rarely as much as 1 m. in diameter. Aplite is frequently associated with the pegmatite, sometimes forming small dikes through the pegmatite, but as a rule irregularly mixed with the coarse-grained rock. The granite pegmatites of Norway are of pre-Cambrian age (a few of them perhaps younger), for the most part occurring in foliated rocks (gneisses and amphibolites), sometimes in granites and gabbros. They may form regular dikes or sills, but often they have very irregular outlines. The geology of the pegmatites is illustrated by sketch maps, cross sections and photographs (Figs. 30–66) from a few occurrences selected as examples and described in the text. An outline of the origin of pegmatites is given.

Chapter III contains general descriptions of the various phases of the utilization of feldspar.

Chapter IV contains a synopsis of the geographical distribution of commercial feldspar deposits. All the feldspar producing districts of Norway (but not the individual occurrences) are mentioned and their location is shown on the map, Fig. 76. Statistics of the feldspar trade are given in Tables X–XPI. Table X shows the export of crude and ground feldspar from Norway to various countries for the years 1912–25. Table XI shows the distribution of this export on different ports. Table XII gives statistics of production for the more important feldspar producing countries.

Die Glasfabrikation. R. DRALLE. 2nd ed. Published by R. Oldenbourg, Münich and Berlin.

The second edition of this book, edited and revised by Keppeler, with the assistance of a number of collaborators, differs in so many respects from the first edition as to be almost a new work. Since the publication of the new edition the technology and practice of glass manufacture have undergone such extreme changes that much of the material contained in this first edition has been omitted from the second edition. Whereas much of the theoretical material contained in the first edition was limited to the views of the author, the editors of the second edition have endeavored to include the most reliable views obtainable on all doubtful points. The text throughout is accurate, clear and readily understood and the photographs and drawings are excellent. The editors have evidently made a careful and complete search of the existing glass literature and have incorporated in the book all the material and views which appear valuable and sound. While this has added greatly to the value of the work as a book of reference, it has detracted from its value as a text book; the inclusion of so much matter in fine print makes for tedious and eyestraining reading; some of the chapters are too long and top heavy; the book in places gives the impression of being overstuffed and loosely constructed; and the lack of a detailed index makes it difficult to locate any desired information. Some of the views presented by the editors, for example, those relative to gases in glass, will be found novel and interesting. This is the first book in glass technology to give the results of accurate and systematic investigations on glass viscosities, reviewing, as it does, the work of Washburn and Shelton on this subject, it is to be regretted that the results obtained by the English investigations on the same subject were not included. It is somewhat surprising, also, that no mention is made of that characteristic of glass termed "nature" by the old glassworkers, although there is sufficient evidence as to its actual existence. With the literature of the technology and practice of glass manufacture growing as rapidly as is now the case, it would seem best to omit from a book on the subject all matter which can be as readily obtained elsewhere; for example, while the manufacture of tank block and glass pots is intimately connected with the glass industry, in fact, the amount of these materials still made by European glass makers for their own use is probably large, it would appear that the best source of this information should be a work on refractories and not one on glass manufacture. The book contains a number of errors—although probably no more than should be expected considering the amount of new material introduced—all of which are obvious or of little importance; for example, the varying melting points quoted for cristobalite in the first chapter, Me_2O_4, page 41, etc. From a statement of American practice some of the material in the book is only of indirect interest—in particular much of that relative to the raw material and batch compositions used in Germany. The chapters on furnaces and gas producers and their operation are especially interesting and that on glass forming and treating machinery is unique in the completeness, accuracy and up-to-date treatment of this subject. This is undoubtedly the most comprehensive and authoritative work on glass manufacture, dealing as it does so exhaustively with the practical and technical engineering and chemical sides of the subject, and as such it should be valuable to everyone in the industry. There are few instances in which the

physico-chemical and mechanical sides of an industry are as closely related as in the case with glass manufacture, yet the average glass chemist knows but little about glass forming machinery, leers, or even producers and their operation, while the average glass house engineer is no better informed concerning the fundamentals of glass formation, composition and properties. D. J. McSWINEY

Rapid cost determination combined with constant control of operation in the ceramic and mining industry. HANS POHL. Published by *Tonindustrie Ztg.*, Berlin, 1926.

The book is divided into two parts; the first deals with the ceramic industry and the second with mining. The chief characteristic of this book is the distinction that P. makes between the total cost of the product and the production cost. The difference between the two is the sales cost. Under the production cost is included (*a*) actual production cost such as (1) cost of raw material, (2) direct labor cost and (3) firing cost, and (*b*) the cost of management. Methods of computing each of these costs are given. A short period cost analysis of each type of ware manufactured by a plant enables the management to check up on each department. P. gives numerous examples of this type of analysis drawn from his experience as an accountant employed in the refractory business in Germany. The graphical method of analysis is stressed. The book can be recommended to the plant manager desiring information on cost analysis in connection with the manufacture of ceramic products. F. P. H.

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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIAL

UNIT ORGANIZATION OF CERAMISTS FOR RESEARCH PROMOTION

Such an organization has been an ideal of several organizations. This has been the ambition of some of the members of the AMERICAN CERAMIC SOCIETY. It was the purpose of the Clay Products Institute. All of these ambitions have been thwarted by misunderstandings, by misleadings, and by naturally existing limiting factors.

The AMERICAN CERAMIC SOCIETY is a well-organized collaboration of over 2100 individuals supported by over three hundred corporations. Its financial income consists of annual dues just sufficient to cover the expenses of Divisions, committees, and officers, the results of the efforts of whom are recorded in the monthly *Journal*. To those who know what it costs in labor and money to accomplish as much each year as do the members of this SOCIETY, it is a cause for wonder how so much is done on a $40,000 budget.

Either this SOCIETY should be financially able to set up an advisory research council or the ceramic manufacturers should unite in support of such a council. Such a council would cost between ten and fifteen thousand dollars per year.

Today the ceramic industries do not have an organization for the purpose of ascertaining and coördinating the research facilities of the

country. There are university laboratories and experiment stations, tax supported, which could be working on ceramic problems, experimental and applied, if only they could be given advice as to problems. This is a task which cannot be handled by any one other than a person familiar with such laboratories and experienced in ceramic research and acquainted with industrial problems. It would take the full time, thought, and resources of such a man and he would need to have the constant counsel of a cabinet comprised of representatives of each type of ceramic industry.

If all the laboratories should engage in ceramic research, which they might well do, the results would pay a goodly return on the money invested in support of the council.

There are several fundamental problems on which the private industrial laboratories could with profit collaborate which are now being dribbled along for an unnecessarily long while. Industries make advances by application of knowledge. They must learn what knowledge is applicable and how to make application. The industry that is the slowest in acquiring and applying knowledge is the least progressive and is under the greatest competition handicap. Greater speed in finding and applying knowledge would result from a ceramic research council.

If such a council had been in existence and had been qualified to advise, the ceramic work of the Bureau of Mines would not have been given over to the Bureau of Standards. The futility in the purpose of obtaining economy in money and effort would have been recognized had there been a balance made between the advantages and disadvantages of the Bureau of Standards attempting the ceramic work which naturally is a part of the work of the Bureau of Mines and which no legislation can take from the Bureau of Mines as long as the latter exists for the fundamental purposes for which it was established.

It requires no great amount of courage to say that the advice on which the Clay Products Institute put its whole reliance for future promotional work into the Bureau of Standards Ceramic Advisory Committee was wholly misleading. The only results achieved have been a stopping of all activities of the Clay Products Institute. Naturally, the federal bureaus must be independent of the industries and subject only to congressional control. To place all reliance in a federal bureau and not be organized to make a concerted representation to Congress robs the ceramic industries of ability to obtain adequate appropriation support for the ceramic bureau laboratories and to make effective their advice and colaboration with the men in the bureau.

Industrial leaders, generally, are content to let science and science application develop naturally as it has in the past and always will. As long as civilization is progressive new science facts will be discovered and applied. But that industry will make the most rapid advances which most intelligently surveys the possible sources of information and takes the trouble to bring to them its specific problems. It would pay ample returns on the effort and money expended in a ceramic research council for advising with the research laboratories.

The governmental institutions serve most those who can and do present themselves as applicants for service. The men in public office whether political or scientific have human limitations in all respects, and will serve those who make rendition of service most easy. It is not for control but rather for promotion and advice that it is urged that all ceramic industries, clay, glass, and glass enamel, shall set up a National Research Council. In no other wise can the ceramic industries obtain their just share of the taxes they pay in support of the state schools and the national laboratories. In no other wise can the ceramic departments in the universities and in the national bureaus have the support which is their just due. By no other means can there be a curtailment of overlapping in research and that assurance of having available all known factors and data relating to a proposed investigation. And in no other way can investigations be placed where the facilities and personnel are best equipped for prosecution of each.

With no sacrificing of privacy and complete control in the investigations each may wish to finance, all the companies and associations federated in the suggested National Ceramic Research Council would save much, gain much, and progress much. This is the ideal which has been in the minds and hearts of several who have given sufficient thought to come to a realization of the situation and the possible benefits.

PAPERS AND DISCUSSIONS

To Members of the American Ceramic Society

Commissioners Report On International Art Exposition

The Art Division wants to call your attention very especially to "The Report of the Commission Appointed by the Secretary of Commerce to Visit and Report upon the International Exposition of Modern Decorative and Industrial Art in Paris," extracts from which are published in this issue of the *Journal*. "The Report represents an attempt to present in brief form those elements in the situation that seemed to the Commissioners and coöperating delegates of most significance to American designers, manufacturers, educators, and the general public." The Commission appointed by Secretary Herbert Hoover was composed of Charles R. Richards, Chairman, President the Association of American Museums and author of a "Survey of Industrial Art"; Henry Creange, prominent member of the Silk Association of America; and Frank Graham Holmes, Secretary of the Lenox Belleek Co.

Associated with the Commission were ninety-two delegates appointed by the national trade associations of the country and approved by the Commission; also forty-nine persons prominent in the field of decorative and industrial art were likewise appointed by the Commission and termed "delegates-at-large."

Viewed from such a wide angle as the subject of "Art in Industry" is in the "Report," the Art Division wants to urge the most serious consideration of its suggestions (and warnings) by the manufacturer, designers, educators, as mentioned above.

America now leads technically in ceramics, and if the manufacturers and educators get together, if she is not satisfied with "slavish copying," there is no reason why she should not enter the creative field and become a leader there.

The Art Division, at present, is very active within a small circle but it needs the coöperation of the progressive industrial leaders who influence the general public, and of the heads of educational institutions.

MARY G. SHEERER, Chr. Art Div.

REPORT OF THE ART DIVISION COMMITTEES

The Possibility of the Craftsman's Entry into the Field of Ceramic Art

This Report has been compiled from correspondence between members of the Committee and from the results of their conversations with others so that it has not been possible to offer it as a series of individual papers as originally planned.

The members of the Art Division who have made this Report possible are, Mary G. Sheerer, Chairman, Art Division; Myrtle M.

French, Marion L. Fosdick, Martha G. Westfeldt, Paul E. Cox, A. Marietta Byrnes, Mary L. Yancey, Margaret Cable; E. deF. Curtis.

The primary aim of the Art Division is to lend a hand to any movement designed to raise the standard of ceramic art in the United States. Believing that one of the elements in this plan is to make it possible for more individual craftsmen to make clay and glass their medium of expression, the Division offers the following Report.

It is hoped that the suggestions and information will lay the foundations for a more comprehensive view of the possibilities open to the ceramic craftsman and perhaps will take a step toward bringing the Art Division into closer contact with the technical and industrial work of the AMERICAN CERAMIC SOCIETY.

Much remains to be done but it does not seem wise to go any further until after some discussion at the Detroit meeting. If the consensus of opinion is that the potter craftsman will help the industry and it seems wise to encourage his entry in the field, it is hoped that the Division will plan part of its future programs to cover the subject more in detail.

The Training Necessary for the Pottery Craftsman

BY MARY G. SHEERER

The chief difficulty in outlining the training seems to be that there has not been sufficient discussion of how the craftsman should be equipped and trained and for what purpose. It will give a basis for developing a group of studies through the regular educational committees if vision is developed as to what the student should be when he steps out to earn his living.

We are assuming that the object of any course of industrial art is to enable the student to take his place in the industrial world, and in this case that will mean that he must do one of three things; (1) he must be a ceramic designer working for a factory, or a free lance; (2) he must be a craftsman executing his own designs, or (3) he must be a teacher. Roughly, the opportunities open to a designer in connection with a factory are either in the sales department where his talents and ability will enable him to offer the product of his factory in such a way that it will more easily meet competition, or in the manufacturing department where he will interpret the spirit of the plans in as artistic a manner as may be possible, within the possibilities of factory process and its limitations.

As a free lance he may work with an architect, with a tile dealer, or as a contractor, buying and assembling factory-made products in an artistic manner.

As a craftsman he must design his wares and also execute them. As a teacher he must be able to instruct those who would learn the small part of ceramic art applicable to occupational therapy, or those who want to become designers in any of the many branches of ceramics.

Scope of the Work

A hasty glance at the broad range of ceramic products that are dependent on design or color or texture will make it apparent that those who are responsible for the proper use of these materials ought to have special training.

1. Architectural work; roofing tile; brick for facing, and for decorative trim; large exterior panels; terra cotta for facing and for trim; floors for all types of buildings, rooms, vestibules, sun parlors, porches, public buildings, etc.; wainscots for interior and exterior use; fireplaces, overmantel panels, hearth facings, backs and jambs; linings for pools; edges for walks; decorative tile for garden use.
2. Out-of-door large decorative jars.
3. Interior decorative uses: lamps, vases, bowls, flower holders, umbrella stands, tea tiles, wall fixtures for electric work, door knobs, desk sets, pitchers, etc.
4. Useful ware: dinner ware, of all types; fine china; kitchen goods, and the wide range in between such as inexpensive attractive tea sets, etc.
5. A multitude of original uses to which clay and glass have been put and may again be put as the styles change, such as decorative figures, portrait medallions, penholders, etc.

Training for Work

The potter craftsman must have artistic, technical, and economic training as follows:

1. Good design, good color, and good decoration are necessary in these wares.
2. The man who plans this part of the work must have thorough artistic training.
3. He must be familiar with the process by which his creations are to be made and marketed.
4. He must know his markets, costs, trade discounts, and trade customs.

Artistic Training The usual first year work in the art school comprises training in drawing, both from cast and nature, freehand and instrumental, some perspective and lettering,

and ground work in theory of color and design. These take most of the time at the student's disposal. The course thereafter should be especially adapted to the ceramic products and sufficient time be allowed to include the technical and economic sides.

The ceramic artist need not be an expert modeler but he must have worked in the round enough to be able to think in three dimensions. He does not need to be an architect, but he must know something of ornament and styles and the proper scale to work in. He need not be an interior decorator but he must be able to harmonize ceramic form and color with the other decorations. He need not be a landscape expert but if he knows something of ancient and modern gardens and pools he can accomplish more.

A great deal of this has been made available in print already but it is scattered. The student working alone will flounder through much that is quite unessential. A reading course could be planned but the logical thing (to be done ultimately) is a text book with full references to the original sources.

There are correspondence courses offered in ceramic engineering of proved benefit; a correspondence course in ceramic art would be of value to those who have the facilities and talent with which to follow instruction.

Technical Training The craftsman need not be able to run a brick machine or a pug mill or a jigger but he must have had a chance to prepare clay, and in a small way actually carry out laboratory exercises in every operation that is called for in clay working. He must make original models and plaster casts, produce wares from the molds, and glaze and fire them.

He must be familiar with kiln construction and operation.

All of this the ceramic artist must have in a very sketchy manner as compared to the engineer, for the craftsman need not be a geologist, a chemist, or an engineer. It is not necessary for him to be able to design a machine, or to know the strength of materials. He will never be called on to design and equip a factory. But he must know enough not to design a piece of work that cannot be made in the plant in which he is working.

And in the same way the craftsman or ceramic artist must at least be familiar with cost data. He must be able to read blue prints and design and estimate costs from blue prints.

If he proposes to make garden pots he must know what they will cost him, how he is going to sell them, and how much discount he will have to allow and how big a volume he may expect. How he is going to get this information it is hard to see, but get it he must, or he will not succeed. A good deal of it can be worked out in the school

laboratory and much can be accomplished in a series of short lectures and he can at least be trained to think in terms of products and of dollars as well as in terms of clay, glazes, and colors.

There is no use at this time of giving a list of lectures and laboratory exercises as suggestions for such a course. It is not the purpose of this paper to do any more than state what in our opinion is required for the proper training.

From the angle we are looking at this whole problem, it seems as though the logical way to work it out would be to concentrate on a few well-equipped schools, where at least the last year's work would be given, and then one shop running on a regular operating competitive basis run by graduate students for a year and replaced by a new set the next year. The graduate should be able to earn his living, he should be able to build his shop into a factory, and he should be able to compete with any country on artistic merit, price, quantity, and quality. Later, when the factories realize that art can be made to pay, we shall have a class of trained people who will be able to carry the artistic spirit into factory routine.

Charting the Field of Opportunity for the Artist Craftsman

By Myrtle Merritt French

In making this survey, many sources of information have been sought, the most important of which will be mentioned. The list includes visits to pottery departments of various stores and smaller shops, interior decorating departments, wholesale places, rooms arranged by professional interior decorators, residential sections where homes are just being built, and older homes which have become especially beautiful through use. Another source is through conversation with architects, artists, importers, wholesale buyers, individual potters, manufacturers, laymen purchasing pottery, and museum officials handling exhibitions.

Tiles seem to have at present the greatest opportunities. With the popularity of the Spanish type of home there are many demands for tiles. Even whole rooms may be almost entirely lined with them and possibly a fountain added at one end with special tiles at intervals. Beautiful and ingenious decorations for the water supply, pool, and electric connections may contribute further charm. There is no end to the possibilities of such a problem, which was attractively carried out in an immense apartment house visited. Modern sanitation, as well as taste, encourages the use of tiles in the kitchen, bathroom, and various types of porches, including sun parlors.

Already artistic people with imagination have done interesting things in this field. In children's wards in hospitals, in nurseries and kindergartens, decorative tiles may be installed at intervals among plain tiles, or in panels and borders. Likewise, silhouette tiles may be imbedded in plaster.

Tiles with even surfaces may be interestingly set in cement for the tops of small tables of wrought iron. They make a heavy piece, but, for some uses, they are lovely and practical. For years, tiles have been used extensively about fireplaces, yet it is surprising how difficult it is to buy beautiful ones.

Silhouette tiles, decorated or plain, may be used with mosaic glass set in cement for objects such as table tops, lighting fixtures, sconses, and fountains.

Perhaps the next field of greatest opportunity is the production of garden ware. Great jars, brilliant and beautiful in color (plain or decorated) would be interesting if handled by the artist. Glazed seats similar to small double-headed barrels or boxes would add color to the garden. Fountain heads have great possibilities, a field almost untouched by the ceramic artist. Bird baths and pools have no end of artistic possibilities. Chimneys may be made decorative by caps of terra cotta, and flower pots made more attractive.

Judging from the lamps seen in all sales places, there are few suitable bases made of clay or glass. They are too often an imitation of another material, silly in conception, such as an old-fashioned girl, or an elephant, with a pipe through his back, supporting a light or an overdecorated or unbalanced vase connected with fixtures. Almost no candlesticks are claylike or adequate, and I have never seen a ceramic candelabrum on the market, though there are great possibilities if properly inspired.

Large plates and fruit bowls are popular among people liking pottery and the supply of desirable pieces is far below the demand.

A long search for attractive pottery kitchen sets for storing spices, dried fruits, powdered materials, preserves, etc., proved useless. There were kitchen sets but they had no inkling of an imagination in their creation. Desk sets and children's sets were practically the same, though there were exceptions, and almost no ceramic book-ends expressed an original or reasonable idea.

Beautiful pottery decorations for electric lights have never been seen, except in one exhibition and in the room mentioned above. There were attractive ash trays on the market, but most of them were of foreign make. Nearly every large pottery pitcher for the dining table was made abroad, though there is little reason why it should be.

Artistic, glazed sculpture is seldom seen though the uses could be many, and the technical possibilities are almost limitless, as a visit to museums proves. Churches and other public buildings offer great opportunities for glazed sculpture, beautiful glass, tiles, lights, fountains, containers, etc.

The play spirit may be introduced into ceramics through whimsical pieces of sculpture which could be used as decorative bits of gaiety in unusual tea rooms, book stores, craft shops, etc. An amusing red clay animal patterned with slip painting was seen on the mantel of a tea room which had no wall decoration except gay birds and flowers painted wherever spots were needed. Occasionally one discovers a clay whistle in the form of an animal or bird, but the market could handle many, if they were appealing.

I heard a request that potters produce good and very simple, practical pieces at a low cost for prizes at parties. The price suggested was around two or three dollars, not to exceed five. Several persons have expressed the desire that better lamp bases could be purchased. Those on the market were criticised as being topheavy, too elaborate, or ill-suited to lamps. One importer said, "American things are so perfect, there is no character left."

There are endless suggestions everywhere for those clever enough to observe them, artistic enough to produce the beautiful, and trained enough to execute at a reasonable expense.

In all ceramics, the public is demanding greater beauty, but at present the expression is usually cold and meaningless. In some cases this fault might be corrected by using as a subject matter something symbolic of the object to be ornamented. For instance, one printing establishment used large, glazed tile inserts to enhance the exterior of the building, the subject matter being the history of printing.

The only thing that will satisfy our inherent desire for beauty is a simple, sincere, direct expression of life as Americans experience it.

As a final conclusion, it appears that the potter (as other artists) must know life in its finest form if he would thoroughly succeed.

Art Institute of Chicago
Chicago, Illinois

A Report on the Collection From the Transactions and Journals of Interest to Potter-Craftsmen

By Marion Lawrence Fosdick

The work of collecting the articles from the *Transactions* and *Journals* of the American Ceramic Society was undertaken as part of

the program of the Art Division for the current year. The collection was to include all articles of value to the potter craftsman.

Time was limited, completion of the work within the year was desirable, and payment for the cost was necessarily by subscription. There are misgivings as to whether it has been accomplished in the best way. Typewritten copies are ready and others will soon be available for those who have subscribed, and if it should seem best to enlarge the subscription or to publish the collection for larger circulation, the typewritten copy will at least serve as a basis for development.

This copy includes abstracts of papers of interest to potter-craftsmen. In general only lower temperatures, those not higher than cone 3, are included. Certain high temperature experiments have been included where their conclusions seemed informative to the potter working with low temperatures, as in the case of the behavior of oxides such as zinc oxide with chromium, chromium with tin oxide, etc., where it is possible that any angle of investigation may prove helpful.

In one of Professor Orton's papers, the following paragraph occurs:

> The function of a paper before our SOCIETY is two-fold. On the one hand it is to set forth matters of scientific truth as brought out by investigation or in the laboratory practice. This is the larger function. On the other hand it is to stimulate others to study and to investigate and make known their findings by placing before them the many fields which remain yet untouched by the representatives of modern science.

A large part of the value of the *Transactions* and *Journals* to us lies in their information rather than in their conclusions. The papers give the experience of investigators working empirically, whose results may later be contested or disproved. The papers show therefore the progress in knowledge of ceramic problems, yet are by no means final. Probably they are most helpful from the point of view of their value in stimulating research. Crystalline glaze research, for instance, has been approached from more than one theory and one article is generally a stepping stone to the next. Probably none of them does more than nick the edges of the large field of possible research on this subject. But any of the numerous articles may be stimulating to the ceramic craftsman. For this reason the abstracts have been made very full and as far as possible their author's phrasing has been kept.

The abstracts cover the literature as far as 1926.

Grouping of the articles is according to the sequence of the books and there is an index of the subject matter.

Speaking for my committee, I offer this collection as still unfinished in some ways, perhaps too closely the choice of one potter, but at least as an effort to make available for the potters of this country

valuable research, much of which is out of print and therefore not to be secured outside of libraries. In collecting and rewriting, an effort has been made to do this from the point of view of the student, the teacher of public and private school crafts, the studio worker, and the commercial potter.

ALFRED UNIVERSITY
ALFRED, NEW YORK

The Circulating Library

BY MARY G. SHEERER

The study of ceramic art carries one back through thousands of years; the few remaining examples of some of the most admired periods are only available to those who are able to go to the various museums of the world and spend sufficient time to absorb the color, texture, and form of the pieces.

In pottery, even more than in other artistic lines, it is essential to have an historical background through which we may develop a sense of real values. If the actual pieces are not available, we can at least become familiar with the state of culture of the period, the type of work done, the uses to which it was put, its relative value in the eyes of connoisseurs and something of the methods employed. This we can get from books, for the literature of ceramic art is found in excellently written and well-illustrated books. Unfortunately, these volumes are often limited editions and more than often are quite expensive. Most persons are not in position to own a complete library. Moreover, it is difficult to judge from the title if the volume covers the field from the particular angle in which we are interested. A book of collector's marks is not what most of us want to invest twenty dollars in, but one copy in the library would be of great use occasionally. It was to meet this condition that the circulating library was suggested.

Most of us have a book or two that we would turn in on such a plan and probably a good many would see the advantage of contributing a few dollars for the librarian with which to pick up second-hand copies of much desired volumes.

If the library could also contain copies of the issues of current magazines to which reference is made in the abstracts in the *Journal* it would enable us to keep reasonably up-to-date.

It is, therefore, proposed for discussion and for adoption, if satisfactory at the Detroit Meeting, that the circulating library be formed along the following lines.

The organization shall be known as the "Circulating Library of the Art Division, AMERICAN CERAMIC SOCIETY" and its purpose shall be to collect gradually and to keep for circulation among the members of

the Art Division a complete set of books, now published and those to be published, of interest to students of ceramic art.

The Chairman of the Art Division shall appoint a librarian for one year. The Librarian shall act as custodian of the books and treasurer, and shall also make such rules and fees as may be necessary.

Members of the AMERICAN CERAMIC SOCIETY registered in the Art Division may become members of the Library by donating either one book published at a price of at least five dollars or the same amount in money. These subscriptions shall become the property of the SOCIETY.

The librarian shall prepare a list of books in the library and send it to the members. Books shall be sent to the borrower by mail or express insured, not more than one book every two weeks, and if possible, they shall be routed direct from one borrower to another. The borrower shall pay the carriage and insurance and the librarian shall be entitled to a fee of twenty-five cents for each transaction or book. Cardboard containers and expenses for preparing the list and for stationery, etc., shall be paid for out of the first subscription money, and any balance shall be used for enlarging the library.

When you come to the annual meeting at Detroit, bring a list of the books which you will donate; if you cannot come, send your list to the Chairman, Miss Mary G. Sheerer, and be prepared to offer suggestions to improve this plan so that the plan may be in working order by the close of the Meeting.

The Coöperative Shop, Its Equipment and Organization

BY A. M. BYRNES[1]

The people of the ceramic world are beginning to recognize the need of the artist-craftsman, because in connection with the understanding of the principles of design and decoration, must be the understanding of the problems that come in the execution of the design. Many art schools yearly turn out young men and women with a certain amount of artistic merit which could be used to great advantage in the industry if they could leave the heights of imagination and tackle practical problems.

Few manufacturers wish to become a "prep" school in which the young decorator can secure the proper equipment and experience. The need of a series of small shops established in cities for the use of the artist craftsman, where with the least cost, he may have sufficient equipment to carry forward his individual work, is becoming more and more urgent. This shop could be established on the coöperative

[1] Mississippi State College for Women.

plan and in conjunction with the shop, could also be established a library and a show room.

The average graduate is not in a position to supply himself with a library of artistic and technical volumes and is also unable to subscribe to all of the current magazines which would be helpful in his work. Many students in different cities are laboring simultaneously on the same problem only to find, after many weary hours of labor, a man in a different state had arrived at the same conclusion months, even years ago. A permanent collection of the less expensive volumes and a number of current magazines and reprints supplemented by traveling collections of the more rare or expensive volumes would form a nucleus upon which could be built through years. The dues could be divided, using a certain per cent of club dues for maintenance of the library, of the show room, and of the shop.

The shop itself seems to many minds to be the greatest difficulty to be surmounted. Many youthful craftsmen have neither the money nor the space in which to erect their own shop. The outlay at first is rather heavy, but for a few hundred dollars one could establish a fairly good working shop. In the case of the Coöperative Shop, again a percentage of the dues could be put into a fund which in the end would remunerate the original investors.

The first thing to be considered, of course, is the kiln, which is the most expensive part of the equipment. There are many things which are to be taken into consideration. There is the choice of muffle or open kiln and the fuel to be used. The muffle is the most practical in the small shop. The fuel also is to be considered from the economical and practical side. In a part of the country in which natural gas abounds it is best to use this fuel; in parts where electric rates are most reasonable the electric power is best; in parts where coal is cheap coal is an excellent fuel although not as clean as gas or electricity; it is not only dirty but requires close attention. Kerosene is possibly the most practical of the fuels, being reasonably clean and easily obtained. Different makes of kilns should be investigated and the one most suitable to the section selected.

The next large item on the list would be the ball mill for grinding glazes. Glazes could also be ground by hand in a mortar and pestle, but this is more difficult and not so efficient. A single or double Trojan ball mill may be driven by hand or by electricity and the factor to govern this is a matter of expense since that driven by electricity doubles the cost. A hand-driven machine may later be equipped by electricity.

Sieves of different series of meshes should be secured although in case of need the number of sieves may be cut down using 18- and 40-mesh for grog and slip and 100-mesh for glazes.

Slip machines may be installed but in the case of individual work it is possibly best to have each carry out his own process and make his slip by hand. It may be kept in zinc-lined vats or in five gallon jars for individual use. Beside the larger slip jars a series of glass or earthen bowls should be used for glazes.

Glazes may be applied to the bodies by dipping, painting with brush, and by spraying. The two first-named processes do not need additional equipment but the spraying equipment may range from the simple, less efficient hand spray or atomizer to the more elaborate, power-driven sprays. The choice of sprays would depend entirely upon finances available.

A wheel for throwing is also an important part of the equipment, although this may be omitted at first using molds until it is possible to secure more equipment. There are three kinds of wheel, the peddle machine, the kick wheel, and the electric wheel. The peddle wheel, closely resembling the sewing machine, may be moved from place to place.

A zinc-lined chest or cellar is necessary in order to preserve the moisture from time to time. If necessary, a large earthen jar can be used by each individual in which to keep the clay and piece. But much better is the large zinc-lined chest containing plaster vats. But again, much superior is the cement cellar lined with zinc and with an air-tight door to prevent evaporation.

The kiln, ball mill, cones, sieves, slip machines, sprays, pottery wheel, and clay containers are the largest items to be considered. Of the above, the slip machine, clay cellar, spraying machine may easily be omitted and simpler processes used. The pottery wheel in case of necessity may be omitted and the use of plaster molds substituted.

The glaze ingredients are the last of the group. Many are not expensive, costing five to eight cents per pound. The foundation may be supplied from the general fund, each craftsman to supply the more expensive oxides.

The basic ingredients used are:

	Cents per lb.
White lead	15
Whiting	10
Georgia or English clay	5
Flint	10
Feldspar	10

The various oxides may be added to the list, ranging from twenty cents a pound upward. The basic ingredients may be secured in large lots, thus reducing the price. A pound of the various oxides will last a small shop for quite a while. Oxides in most frequent use are tin,

cobalt, zinc, iron, chromic, copper, manganese, and uranium. Under glaze, stains may also be used, producing desired colors.

The organization of a coöperative club may be constant throughout the group and the method of approach may be varied according to circumstances. An active Women's Club might aid in the establishment of such a club. In a college town one could draw upon the college for those interested in art. A Civic League might aid and the local art club might coöperate in the forming of a coöperative organization. The money may be secured from members or subscription with the obligation to return the loan after a period of years, which would permit the club to grow and justify itself. The kiln may help pay for itself by firing for certain schools at a fixed rate per piece, the pieces to be executed in school, drawing upon the art department of the grammar and high schools and colleges in this way. In many places the teaching of pottery is prevented by the lack of equipment. Thus, there would be a mutual advantage.

The most feasible plan perhaps would be to buy equipment with money collected in the group with the idea of paying later from the club treasury, giving the lender a kind of mortgage on club property. The dues would be as small as possible to permit the operation of the plant. A division of the dues into four parts could be made: 25% for shop, 25% for sales room, 25% for library, and the remaining 25% for general fund. The AMERICAN CERAMIC SOCIETY could send reprints free of charge, and with several subscriptions and the possibility of a traveling collection of books the library would be started and the sales room could help in its upkeep by a commission on sales.

In a small way such a club has been formed at Mississippi State College for Women in conjunction with the Art Department. The girls had no place of their own in which to exhibit their wares. A small brick building was given to the Club, a laundry which was no longer in use. The pottery-making room was in the building with the Art Department but since it was not possible to put the kiln there, the second room in the old laundry, now Art and Crafts Shop, was used as the kiln room.

In Boston there is an organization known as the Pottery Workshop which has been running several years. It is composed of a group of about twenty people who share the operating expense and the expense of a man to do the heavy work. It would add a great deal of interest to craftsmanship if there were such a place in each large center where those who are able to work in clay could carry on. Such a place would not be expensive to run and the members might arrange with some professional craftsman to run it for them by giving him some salary and the use of the shop. The public school work will always fall short

of what it might be, as long as it is denied the kilns. A shop of this kind might easily arrange to fire the best pieces.

The Small Shop[1]

By E. DeF. Curtis

In a paper "Industrial Potter Craftsmen,"[2] the author states:

> We must work out a small shop, large enough to be more than a toy and cheap enough to allow the average student to tackle it, with blueprints, costs, and specifications. With this we must publish a definite standard method of working from which he may deviate according to his ability to experiment, but on which he may fall back in time of excessive loss.

In working out this problem I have used my own shop and the equipment in use at the Pennsylvania Museum and School of Industrial Art as a basis, not because it is ideal, but because it has stood the test of time and will fulfill conditions.

Description of the Process

The clay, just as it comes from the mine, is put into a washtub, spread about three inches deep, covered with water, and allowed to soak for twenty-four hours. It is then put into a churn with more water and about ten pounds of 2-inch flint pebbles, and ground for fifteen minutes. The very thin slip is screened through a fine kitchen strainer and stored for about forty-eight hours in a washtub until it has settled. The water is siphoned off and the mushy clay is put into plaster troughs to dry. As soon as it can be rolled up without sticking to the hands, it is put into an old refrigerator until wanted. The clay at this time is of suitable consistency for throwing, pressing, building, or modeling.

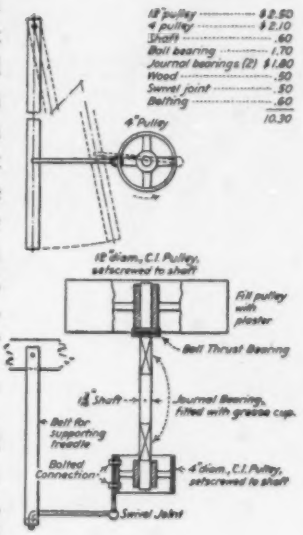

FIG. 1.

If the piece has been thrown on the wheel it is put in the damp box over night, marked, turned down on the bottom and put on a shelf to dry. If a mold is wanted, the original shape is turned on the wheel out of a solid lump of clay, and the mold made over it.

Tile shapes are pressed in plaster molds. The ware is not biscuit fired unless the piece is very thin. Thirty pounds of glaze are ground for forty-five minutes in one part of a solution of 5 pounds of gum

[1] Received November 24, 1926.

[2] E. deF. Curtis, *Bull. Amer. Ceram. Soc.*, 5 [3], 177–79 (1926).

arabic well dissolved in five gallons of water and two parts of water, screened, and allowed to settle over night.

The open flame kiln described in this paper is not a good kiln for biscuit ware as the flame is likely to leave a smear that will not take the glaze. The biscuit should be fired soft or protected from the direct flames.

Any of the well known decorative methods may be used; the air brush is a most valuable tool. The pieces are then fired in the open flame kiln.

Clay Used

One part by volume of Johnson-Porter Tennessee ball clay, one part of flint, and six parts of almost any red Pennsylvania clay makes a fair body for both casting and throwing. The Tuckahoe clay from Wm. G. Moore and Co., Drexel Bldg., Philadelphia, is excellent. The average price of these local clays is about $16.00 per ton in lots of one ton or less including freight and haulage. The mixture averages about $20.00 per ton or one cent per pound.

Dry clay will make slip in less time and with less effort than damp clay. It is better to use time than power.

Fine grog may be had from firebrick plants for about the same price as the mixture described.

The Open-flame Kiln

Twenty of the open-flame kilns have been built and operated. Of these twenty kilns two only were failures.

The kiln is inexpensive to build and inexpensive to operate. The repairs are exactly nothing. It does not require a stack and is not dependent on weather conditions. The kiln may be loaded and fired in one day. The spaces between the saggers and the sagger walls are not being heated. All the heat except what the walls absorb goes into the pots in the kiln. Since the kilns are inexpensive several may be had to allow for a large volume of business and while idle the money expended does not amount to much. There is complete control of the atmospheric condition in the kiln and complete control over the rate of firing.

Since the flame comes from only one direction it is difficult to keep a tall thin piece from warping, but it can be done by selecting the even pieces in the kiln. The greatest objection is the difference in temperature from the bottom to top. The heat can be driven back with more pressure, diverted to the front with a baffle, and spread to the sides at will, but the top is a problem that so far has not been solved. We fire to the top and put hard enough glazes in the bottom to stand the heat.

There have been so many inquiries since the first description of the kiln was published[1] that it seems advisable to furnish the complete details.

The heat must be brought up slowly so as not to explode the ware, since until it is red there is moisture left in the clay. As soon as the ware is red the heat must be brought up as steadily and quickly as possible. The flame may be diverted on an angle; but not altered abruptly.

Having made sure that all pipe and hose connections will not leak under a pressure of 50 pounds, the relief valve is opened on the oil tank so that the oil will run in quickly and fill the tank. A good grade of kerosene is used. Before connecting the burner to the tank open the valves and blow through it. If it is not free clear out any obstruction. New burners sometimes are choked with sand and scale. Connect the burner with the tank, pump up to 40 pounds and open both valves. The oil should shoot into the kiln in a thin stream.

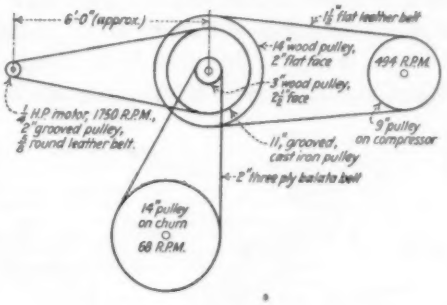
6'-0" (approx.)
½ H.P. motor, 1750 R.P.M., 2" grooved pulley, ⅝ round leather belt.
14" wood pulley, 2" flat face
3" wood pulley, 2½" face
494 R.P.M.
9" pulley on compressor
11" grooved, cast iron pulley
2" three ply balata belt
14" pulley on churn 68 R.P.M.

FIG. 2.

Preheat the burner by lighting an oily rag under the nose and another one under the brass nozzle. As soon as the burner is hot, (about five minutes), open the oil valve a little. The vapor will come out the brass nozzle and burn. The burner, at first, must show a slow red flame not reaching the first shelf. Starting the burner is the only difficult part about the operation of the kiln. Let the flame burn this way for an hour and then, holding the pressure steady at about thirty pounds gradually open the valves so that at the end of another hour the burner is at its full speed.

When the flame is on full it will show blue at the nozzle. The flame must not be swirling back to the end of the kiln. The end of the flame should be just under the first shelf of pots.

When the burner is on full speed the lower bricks should begin to show red at the end of one-half hour. If they are not red the adjustment is wrong: too much or too little oil, too low pressure, air entering

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[1] E. deF. Curtis, "The Course in Pottery at the Pennsylvania Museum School of Industrial Art," *Jour. Amer. Ceram. Soc.*, **8** [3], 138–42 (1925).

the kiln around the burner, or the outlet hole at the top of the kiln is too far closed.

The burner will in time clog with carbon. This will cause the use of more pressure. When this happens the burner should be taken apart and burned out at a garage just as the carbon out of an auto cylinder is burned out.

Each time the kiln is fired the screen on the strainer valve, and the brass nozzle should be examined. If, after the kiln is red all through and the valve open one full turn with a pressure of 35 pounds a flame is not visible at the top hole in each it will be certain that burner nozzle is clogged or burner is carbonized.

Three different burners have been used: one made by the Hauck Mfg. Co., Brooklyn, N. Y.; one made by the H. H. Kress Co., 1718 Sansom St., Philadelphia, and one home made burner. The latter was designed to overcome the difficult starting of the Hauck and the lack of "pep" of the Kress. The Hauck burner is their No. 9F hand pump vaporizing type. It has a coil of pipe where the oil is preheated and a hollow nose where the vaporizing is done. The hole in the brass nozzle should be reamed out with a No. 50 drill.

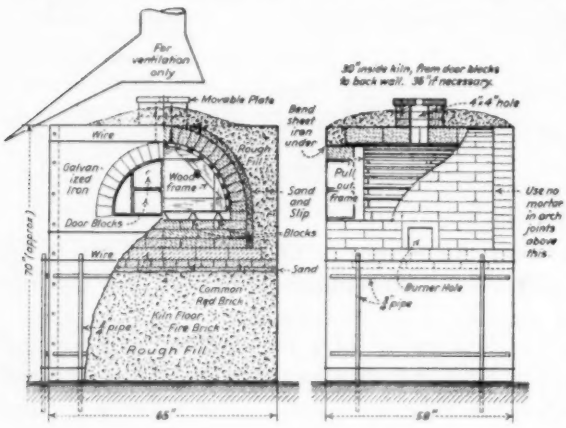


FIG. 3.

The alternate rushes of liquid oil and vapor caused by the coil in slow starting, makes the Hauck burner surge and blow out. Two ways have been found to overcome this trouble: by keeping the pressure down to fifteen pounds and a ball of asbestos wicking soaked in oil as a pilot light until the burner is working full speed, and the surging stops, or by slipping a piece of tin over the hole into the kiln so that none of the flame gets into the kiln, then gradually this tin is pulled away and very little flame is let in at a time.

The Hauck will burn more cleanly than will the Kress and the coil will give more preheating surface, but the Hauck will clog from carbon sooner than the Kress. The Kress burner, although very good, is a little bit small for the kiln. The hole in the nozzle of the Kress must be a

No. 536 or the oil will go through so fast that the hollow nose of the burner is cooled and gives too much flame into the kiln. The oil in the nose will also carbonize.

There is no trouble with starting the Kress burner. The valve is set, the pressure gradually increased, and the valve is opened until a blue flame is obtained.

The nose of the burner must not stick into the tunnel where it will get red hot and neither the top damper nor the burner opening must be closed too much.

When the final temperature has been reached, the valve is shut, some bricks are put over the burner hole, the top is left open and the kiln is cooled.

The best time made with this kiln is from 9 A.M. to 3 P.M. using 12 gallons of oil and bending cone 3 flat, but this speed is unusual. The secret of time saving and oil consumption is to keep the right pressure steadily and that is the reason a large air tank supplied by a small compressor is best.

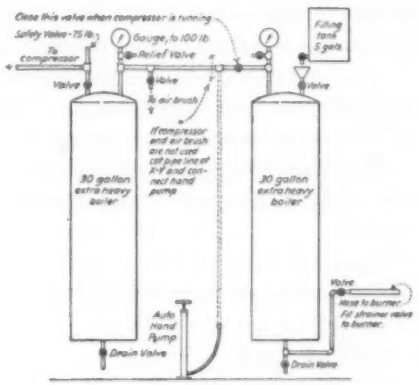


FIG. 4.

If the valve gets warm while the burner is heating it will cool down as soon as it is opened and cold oil is let through it. If the valve gets hot it is a sure sign that the valve is too far open letting more oil in than the burner is using and forming a reservoir of hot oil that will gradually work back into the tank.

When using a compressor and air tank *do not run the compressor unless the valve between the air tank and the oil tank is shut tight. It is dangerous.*

Operating Costs

With $1500 invested in a lot and building, and $300 in equipment, the fixed charges on this will be about $100 per year. On 50 kilns, one a week, the overhead on each kiln is $2.00. The cost per kiln would be: clay, $.60, glaze, $1.00, power, $.50, cones, $.05, oil, $2.25, depreciation, $.50, tools, $.50, overhead, $2.00; making a total of $7.40 per kiln.

The kiln will hold ware which at current prices and discounts will net about $50.00 or a margin per kiln of about $45.00.

If a craftsman can develop a style, a color, or a design that lifts his work out of the ordinary he can make the kiln pay at least double. This is the key note to the craftsman's financial success; turning his individual expression into something for which the public will pay.

Differences in ability and in ideals are all too variable to say, here is something you can make; the idea of this paper is simply to show some simple methods of working, and to show that the chance is there for those with the proper training and courage.

The Field

It is perhaps a little exaggeration to say that a one-man shop could compete with roofing tile as a product, but if the great heavy tile used on small buildings are considered it will be agreed that smaller shingle tile would find a limited market; and the craftsman is not after volume. If the craftsman competes with the modern factory he is done before he starts; but if he makes his tile into table tops for gardens, if he treats a fire place, facing, hearth, and perhaps backs and jambs, all as subjects of applied design, he can get ample returns for his work. Does a painter sell so many square feet of canvas?

Where is the factory with mass production that can put individuality into big outdoor pots? One man with two kilns can do it and make it pay well.

The fact that he has been thinking of himself in terms of fine arts instead of useful arts is what has held back the craftsman. Pottery is an industrial art. Price, competition, and markets must be considered. A good price can be gotten for work well done.

Just because ware is hand-made does not add real value to it in the eyes of the buying public. The craftsman must give true worth, he must put his brains and brawn into his work and make it show something that the factory can never put there.

CONESTOGA POTTERY,
WAYNE, PA.

Publicity

BY E. DEF. CURTIS

A consideration of the possibilities of increasing interest in ceramic art has led us to the following conclusions: (1) there are many agencies at work now with whom the Art Division may coöperate; (2) there are many activities the Art Division could sponsor if it could finance them; (3) the greatest influence that can be brought to bear on the public will come through the development of taste and judgment as to what is good design and workmanship.

Expanding these conclusions we may say of the agencies now at work:

1. The American Federation of Arts is willing to publish suitable articles on ceramic art. Each year they send out a traveling exhibition of modern pottery and are of course a tremendous influence for good in the world of art. Closer coöperation with them would increase the sphere of influence of the Art Division. The Division could keep in touch with them and from time to time offer articles. The SOCIETY could publish the routing of their exhibition.

2. There was a plan suggested at the Atlanta meeting to borrow from the museums some pottery and form a traveling exhibition to go to the factories for several weeks at a time. The Committee has tried to get this into shape but up to the present time has not been able to get a definite expression from the authorities as to whether or not they will lend important pieces for the purpose, or whether or not they will allow large color photographs to be made to be used as transparencies. They are interested to some extent because one of the museums has had a moving picture made of the pottery processes for use in their educational campaign.

3. The Art activities of the women's clubs should be utilized. Last year there were several traveling exhibitions of pottery sent out by the General Federation, composed of some sixty pieces of ware from representative American potteries and shown to more than sixty clubs and colleges. The lecture was written by Florence Topping Green, Secretary of the Federation, and was accompanied by a moving picture made by Lenox. Work should be done with those potters who are willing to exhibit and with these clubs.

4. In nearly every large city there is some organization like the Arts and Crafts Society which would be glad to have an inexpensive folder to give to their customers about the aim of the modern potter. The Boston Society of Arts and Crafts is to hold a tri-centennial exhibition of Arts and Crafts at the Boston Museum of Fine Arts in March, 1927, and it is interesting to quote from their letter, "We hope you will not fail to have something distinctive in form, glaze, and decoration to submit to the Exhibition Committee before February 15." It is to be noted that they ask for ***distinction*** and that the work must pass a jury.

5. Of the activities that might be sponsored by the Division there are exhibitions, publications, and prizes to bring out the best work. A collection of color plates that have been published in books and magazines could be subscribed for while the plates were still available. There are lectures and traveling exhibitions for schools, but all of these are out of the question until the Art Division has a large enough membership to carry the financial load.

Schools and architects are interested from quite different angles and the whole field is so large that a fund must be available before the

situation can be handled intelligently. Stimulation of interest in standards of ceramic art through architects, tile dealers, interior decorators, and individuals will be largely through illustrations, publications, and exhibitions.

CONESTOGA POTTERY
WAYNE, PA.

REPORT OF COMMISSION APPOINTED BY THE SECRETARY OF COMMERCE TO VISIT AND REPORT UPON THE INTERNATIONAL EXPOSITION OF MODERN DECORATIVE AND INDUSTRIAL ART IN PARIS, 1925[1]

The International Exposition of Modern Decorative and Industrial Arts held in Paris in 1925 was unique among expositions in two respects. On the one hand, it was the first international exposition to be limited strictly to the field of applied art as distinct from fine art and from manufactured goods and raw materials in general; and on the other, it was the first international exposition to be confined to works conceived in the modern spirit and not based on the older recognized styles.

Genesis and Development of Modern Movement

The modern movement in industrial and decorative art may be said to have had its important beginning in several European centers in the last decade of the nineteenth century. In Paris, in Vienna, and in Munich the expression of new tendencies in decorative design manifested themselves during this period in various fashions. In one case the new movement took form in architecture, in another in decoration, in another in handicrafts.

The first important presentation of the new movement occurred at the International Exposition held in Paris in 1900, where among other novel expressions the Art Nouveau creations of the Establishment Bing attracted universal attention. The displays of 1900, however, had a very stimulating effect upon applied design not only in France but in Germany and other countries, and although the particular motives of l'Art Nouveau soon fell into disrepute, the stimulus toward creative design in a modern spirit persisted.

This was particularly true in Germany, where the movement was organized to a remarkable degree. The Deutsche Werkbund, composed of public officials, industrialists, merchants, architects, artists, designers, and craftsmen, together with a number of subordinate associations, preached the value of German leadership in the movement and pushed forward the merits of the new creations in the fields of commercial production and public undertakings. For fourteen years the buildings of great corporations and department stores in Germany were built in the new style. Garden cities were planned and constructed, while the smallest details of printing, advertising, and display were studied. These organized efforts were nation-wide in their scope and undoubtedly exercised a considerable effect upon the export trade of Germany up to the time of the World War.

Since the war, if I may quote a French writer, "France has taken a leaf from Germany's book," and had apparently resolved no longer to rest content with individual initiative and effort in this field. Instruction in the modern quality of design is now offered in all the schools of applied art throughout the republic.

The large department stores have inaugurated a special department that offers all kinds of material conceived in the modern spirit and has placed at the head of this department an individual of talent and reputation in this field, who, with a staff of

[1] Charles R. Richards, Chairman, Henry Creange, Frank Graham Holmes.

designers, personally designs and superintends the design in his own studio of much of the material offered by his department.

The Société des Artistes Décorateurs holds a salon embracing the field of the industrial arts each spring and fall in the Grand Palais.

The Musée des Arts Décoratifs and the Musée Galliera hold frequent temporary expositions. The first named museum is administered by the Union Centrale des Arts Décoratifs, a body composed of artists, architects, industrialists, and amateurs. The Musée Galliera holds three or four exhibitions in some particular field of applied art each year.

Trade associations have been instituting competitions with liberal prizes for designs of objects within their special field. Finally, as the culminating recognition of a national attitude, France organized and carried through the International Exposition of Modern Decorative and Industrial Arts in 1925.

In this Exposition all the nations of the world were invited to participate. The four chief sites allotted to the national pavilions were reserved to the four major allies of France in the World War—Great Britain, Italy, Belgium, and the United States. The invitation to the United States was declined on the ground that American manufacturers and craftsmen had almost nothing to exhibit conceived in the modern spirit and in harmony with the spirit of the official specifications.

The great attention given to instruction in the applied arts throughout the national regional and municipal schools of France as evidenced by the displays at the Exposition is one of the factors responsible for the vitality and high quality of French decorative and applied arts.

Conclusions

Coming to those considerations that relate more particularly to our own conditions your Commission submits the following opinions:

First, that the modern movement in applied art is destined to play a large part in the near future in many important fields of production throughout the western world.

Second, that the nation which most successfully rationalizes the movement and brings its expression into terms acceptable and appropriate to modern living conditions and modern taste will possess a distinct advantage both as to its domestic and its foreign trade.

Third, that the movement will undoubtedly reach our own shores in the near future and unless we are to be entirely dependent in this juncture upon foreign talent, manufacturers, designers, and school authorities should take careful note of its course abroad and endeavor to initiate a parallel effort of our own upon lines calculated to appeal to the American consumer.

Fourth, that the problem of developing a new quality of industrial design in America is very different from that in Europe. There the small establishment and small output renders variety in design comparatively natural and simple as contrasted with our practice of mass production.

As a nation we now live artistically largely on warmed-over dishes. In a number of lines of manufacture we are little more than producing antiquarians. We copy, modify, and adapt the older styles with few suggestions of a new idea.

The modern movement in industrial art if approached intelligently and courageously by American manufacturers may well be the means by which our country will achieve a larger measure of artistic independence. If this is to come about and we are to develop something pleasing and rational in this new field, something that will keep in mind our traditions and yet renounce slavish copying, it must evidently be through our progressive industrial leaders. They command the best talent, possess the greatest courage, and exert the largest influence. If they can be inspired by the example of European nations to leave to some degree the fixed paths of our present practices and to venture with

cautious courage into new fields, we may well reap real advantage both economically and aesthetically from the modern movement.

Conservatism in the field of applied art is with us often regarded as the best means of holding local markets. It is manifestly not the way to protect us from the incursions of foreign competition or develop the possibilities of our own foreign trade, nor is it in itself the best means through which to develop an industrial art by which American homes may reach an expression truly appropriate to the social and living conditions of the twentieth century.

QUANTITY PRODUCTION IN ART INDUSTRIES

HENRY CREANGE

The elimination of waste in industry can be effected not only in those fields where the problem is purely an industrial engineering or mechanical one, but also, to a great degree, in those industries where art is an essential element and where frequent style changes tend to complicate the issue.

It is the purpose of this paper to present a practicable plan whereby the various factors which enter into the creation of an art product can be so coördinated as to secure comparative safety in large production for art industries, without sacrificing that leadership in creative ideas which must be taken if America is to occupy its rightful place in the world of industrial art.

American industry does not really attempt to watch and understand local and world influences in style and art as it does local world statistics in food stuffs or raw materials. And because of this it is constantly caught unaware and loses out. And because it has lost out much and often it has become timid, lacks initiative and tends to stifle creative effort.

A thorough analysis of the conditions will reveal that there is no valid reason why creative effort should not function in large industry as well as it did in the past among artists and craftsmen, unhampered as they were then by important financial and national distribution problems.

The application of artistry and individuality to any given product introduces elements which require further knowledge; that is, art of creation, art of design, craftsmanship, knowledge of public taste.

The danger that attends quantity production typical of American industry lies in the fact that the introduction of novelties when attempted is generally performed without relation to that proportion of the product that can safely be made new.

A manufacturer's line planned and made up in the right proportions of:

Phase I. Entirely new ideas—novelties

Phase II. Developed versions of the preceding year's successful creations (including staples)

Phase III. Developed versions of the preceeding year's successful creations (including dustries

has in it an element of safety not obtainable otherwise.

Phases II and III are really based on an identical theory, but because manufacturers are in possession of accurate knowledge in Phase II long before they can become acquainted with the elements needed for the preparation of Phase III, Phases II and III are classified under two separate heads.

The Three-Phase System is applicable to everything affected by style or fashion changes, forms, colors, designs. The proportion to be accorded each phase in the planning of lines is determined by conditions, policies, sales statistics, etc.

The system eliminates much of the element of chance that is found in launching novelites, limiting the main risk involved in really new creations to the proportion accorded with full knowledge to Phase I.

It permits of such advanced planning and assures continuous employment of the mill hands concerned with the research, designing, and sampling. Often it allows advance manufacturing on a fairly safe basis.

It gives greater facility and freedom to the creative sections of manufacturing because:

1. The creative work is split over a longer period of time, the first part of it being made to cover Phase II, followed up by Phase III, and finally ending—at the last minute—with Phase I.
2. Phases II and III operate as a safeguard against loss of business resulting from too radical and too sudden changes in the product, and
3. The advance knowledge gained through the testing out of Phase I prepares material for the constant renewing of Phase II.

It is quite evident that were a large industry to attempt to create novelty leadership it could not possibly afford to risk its entire product on ideas that have not yet proved their worth with the public, and yet unless such ideas are tried out novelty leadership cannot be accomplished.

To split up the product into three phases, devoting only one part (Phase I) to what might be termed the "launching" but what is really the "testing out" of novelties, is to take an important step towards eliminating waste.

Phases II and III will bring sufficient business to keep the mill fairly busy and earn enough to finance the creative effort necessary in Phase I.

Even within this last phase (I) the Three-Phase System should be applied. For in a new creation it is entirely unnecessary, and even unsafe, that every element be novel.

To blend the old with the new, to embody some element that has already been accepted by the public is to start that creation with a very fair chance of life. Creation that departs too radically from the past, that throws into discard all that has gone before, is apt to be short-lived. The continuity of nature, the natural law that creates new forms step by step, by an evolutionary process in contradistinction to a revolutionary one, may well be followed in the industrial field. Very few understand this principle, but those few are achieving really worthwhile things and are doing constructive work.

Experts in Art Direction

All of which points to the inevitable conclusion that American large-scale industry, just as it has in late years installed in its mills efficiency experts, attached to the accounting and production, and just as commerce has in the past decade acquired merchandizing experts, should now maintain experts in Art Direction as part and parcel of its executive staffs.

Professor Charles R. Richards, in his book entitled "Art in Industry," concludes that there is a need for "super-designers." That is well, but it does not go far enough.

Every department in the Mill, and eventually the Advertising and Publicity sections which support Distribution, and Distribution itself, must be guided in turn toward a definite goal—a thorough understanding and the proper interpreting and support of the "Creation."

In each of the activities of modern manufacturing affected by changes in fashion or style and in which the transformation of the product plays a part—and few industries escape this influence—and understanding of ultimate aims is a constant necessity. It affects the selection of information, the creation, the execution, and the distribution, each in turn.

Perfect harmony between ideas gathered from every avenue of thought implies very careful work, tireless labor and research, a thorough knowledge of the classics, refined and trained taste, a sense of tone, beauty, and perfect technique.

It is time for American industry to realize that such requirements call for the service of specialists.

No product can become a perfect vehicle if it is allowed to wander through the various departments of a modern mill without direction.

Nor is it true that Art Direction is a thing that can be successfully accomplished without such training in the arts, accompanied by thorough knowledge of the markets to be served and the influences at work in them.

American industry must cease to treat art and artists as separate and apart, but the artist and his art must receive guidance.

America should now take her place among those nations bent on expressing themselves. No greater recognition may be given the French for their courageous enterprise than our acceptance of their courteous challenge, and opening wide our markets to them, which their creative initiative so richly deserves.

But ours need not be the rôle of lookers-on. America will slowly feel her way in this new expression of art but will not neglect it, just as she should maintain contact with all things created everywhere, developing at the same time her own creative genius.

Quantity production is not necessarily an obstacle to artistic effort or novelty creation.

When properly organized, the possibilities of larger industry are greater than in smaller units, where all the revenue must often be earned out of a single item.

America should lead in the establishment of national as well as international industrial art agencies for the classification and dissemination of art and fashion knowledge, for nothing is so international as art. Organized art direction at home backed by art guidance and understanding from abroad ought to result in America taking her place among the nations who are making worthwhile contributions to the arts and trades.

Art and Industry of Ceramics[1]

France has always excelled in the field of ceramics and in the last thirty years a remarkable revival has occurred in this field, in which the inspiration has come largely from the Orient. Some thirty years ago the art of the early Chinese potters of the Tang and Sung dynasties became known in Paris. Certain French craftsmen, notable among whom were Carries and Chaplet, became possessed of the desire to discover the secret of these beautiful glazes. Their researches were in large part successful and with them was initiated the modern French art of high-fire stoneware, the products of which present little or no surface ornament but depend for their decorative effects upon the sober, deep and rich glazes produced in the kiln. August Delaherche, beginning in the late nineties of the last century, brought this art to a high state of perfection and in his long career has produced a great number of beautiful pieces now well represented in European museums and in private collections both here and abroad. Today this important branch of decorative art is represented by men of a younger generation, at the head of which stand Émile Decoeur and Émile Lenoble. The former in particular has reached a very high plane of achievement. His untiring experiments, guided by superior intelligence and high artistic taste, have brought to the art of grand feu stoneware and porcelain, it is safe to say, a richness and refinement unattained before in modern times.

The achievements of these French potters is dwelt upon at some length because we have in this country very little decorative ceramics of the high fire type. With the exception of the work of Mrs. Robineau and Charles F. Binns and a few experiments made at different places at various times, our decorative pottery has been of the low fire type covered with easily fusible glazes. Some of this work is extremely interesting and attractive, but it lacks certain artistic qualities, notably depth and richness of tone, that come only through the high fire kiln.

[1] From "Report of Commission appointed by Secretary of Commerce to Visit and Report on the Modern Decorative and Industrial Arts" in Paris, 1925.

Decorative stoneware of the kind noted above requires craftsmanship of a high order possible only when the worker possesses thorough technical equipment combined with intellectual energy and fine artistic taste. Whether our American conditions will allow the support of such high-grade craftsmen remains to be seen.

In addition to the work of these artist-craftsmen whose creations must be ranked as articles of luxury, there was in evidence at the Exposition much attractive faience of an inexpensive type. In the Bon Marché exhibit there was much of such work marked by attractively colored designs outlined in black on a cream-white surface. The Printemps exhibited a large variety of inexpensive ware, some in white crackled matt glaze, some in stoneware, and some in iridescent effects. Some very interesting modeled figures were prominent in this display. Other establishments like Faux-Guillard displayed attractive examples of modeling and of decorated pottery.

There were a number of interesting displays in the field of decorative ceramics from foreign countries, notably in the case of Denmark. Two very important commercial establishments in Copenhagen, the Royal Porcelain Manufactory and the firm of Bing & Grondhal, have done much of late years to revivify the art of decorative porcelain and stoneware that do not appear in this country. Of particular interest among these are the high fire stoneware with glazes réminiscent of China, and figurines from the hands of Gerhard Henning and Jais Nielson. Bing & Grondahl have also developed many novel technical effects, and by granting exceptional freedom to their artists, who commonly make as well as design the new creations, have produced some very fine and individual expressions of ceramic art.

Another firm that produces some interesting decorative work is that of Kahler of Copenhagen. Many of the plates and vases, sometimes with iridescent glazes produced for this firm by Jens Thirslund, are of exceptional attractiveness.

In table china the French displays were not noteworthy. The designs in French decorated tableware are on the whole rather conventional. They are not marked by novelty or by exceptional beauty of form or color. In this regard they are excelled by the English products which are oftentimes most colorful and attractive in design. It is to be noted also that a considerable proportion of the English tableware is made of earthenware and not of china. This earthenware is of a relatively hard body but being coated with glazes that are set at a considerably lower temperature than is the case with china, it permits of the use of a larger palette of colors for decoration and gives a much softer effect.

Art and Industry of Glass

During the last thirty years France has developed a veritable Renaissance in the making of decorative glass. Beginning with Galle in the late nineties, with his exquisitely colored overlays, this Renaissance has produced techniques and effects of color and form never before compassed in the history of glass-making.

Among the most prominent artists in this field are Lalique, Marinot, and Goupy. Since the World War Lalique has turned almost his entire attention to the art of decorative glass and in this field his prolific genius has evolved a great variety of interesting effects in form and color hitherto unknown to the glass-maker. Most of Lalique's productions are made by blowing the glass into a metal mold and are consequently capable of reproduction. Some of his creations, however, are made with the use of clay molds which are destroyed at the completion of the operation, and these pieces are consequently unique. He has also produced a number of interesting designs for table glass which sell at very moderate figures. These latter productions of Lalique are especially noteworthy as they represent a serious attempt to bring the modern art movement into the life of the general public through articles manufactured on a large scale from models and designs which have been carefully worked out from the beginning.

Maurice Marinot is often referred to by his countrymen as possessing the greatest artistic genius of any of the workers in decorative glass. He creates in many different techniques. Some of his productions are very solid, substantial forms of bottles and vases in which the glass is permeated with bubbles giving interesting and peculiar effects. He also produces bottles in other forms in which the design is left in relief by very deep etching. Another of his modes is that of enameled glass.

Marcel Goupy works entirely in enameled glass. In this case enamels of various colors are used to produce a design upon a body of clear or colored glass. Many of these productions seem more like the work of a decorator than that of a glass-maker. This work is less expensive than those of the other producers mentioned above, and is, of course, capable of an infinite variety of forms and colors.

Another form of decorative glass is that called by the French pâte de verre. This is made by filling plaster molds with glass powder and firing it at a heat just short of vitrifaction. The superposition of vitreous powders of various colors produces a marbled or tortoise-shell effect. By reason of its density and thickness and depth of tone, pâte de verre is intermediate in appearance between ceramics and glass. François Decorchemont, the leading exponent of this art, has achieved a remarkable series of translucent jade-like effects in bowls and vases of different colors which constitute a distinct contribution to the arts of decoration.

Dammouse has also worked with rare skill in this field and produced some very light and delicate works which in this case have been built up by hand.

Besides the work of these leading artist craftsmen there are a large number of commercial establishments that produce very interesting works in decorated glass at a much lower price. Notable among these firms is that of Daum Frères of Nancy, which produces mainly enameled and etched decorative glass. This firm and that of Majorelle produce much interesting glass for electric light fixtures.

Walter of Nancy and others produce pâte de verre in many shapes and colors which sell at very moderate figures.

The Compagnie des Cristalleries de Baccarat and the Cristallerie de Choisy-le-Roi are large concerns mainly devoted to the production of table glass. Their productions did not seem to reach the excellence of design that might be expected from establishments of such reputation. The first named company also produces decorative glass which is apparently inspired by the work of the artists mentioned previously.

Another form of decorative glass that attracted much attention at the Exposition was the engraved glass represented by the productions of Orrefors, Sweden, and J. & L. Lobmery of Vienna. In the United States we have few traditions of engraved glass. In Central Europe, however, this art was carried to great elaboration in the seventeenth and eighteenth centuries, and the two establishments noted above are responsible for a remarkable revival of this art in modern terms. In both cases artists of the highest quality have been employed to produce the design and the highest type of technical skill is made use of in cutting delicately modeled figures and other elements of the design. The productions in both cases take the form largely of decorated glass for the table such as bowls, jars, vases, and bottles.

Czechoslovakia exhibited large quantities of inexpensive cut and engraved glass, very little of which presented artistic merit. On the other hand some very interesting and low priced table glass was shown by Sweden. This was smoked or tinted as to color and Venetian as to technique.

The whole field of decorative glass as represented at the Exposition suggests very important possibilities to our manufacturers. Decorative glass has figured to a very small extent in American consumption and we have only of late years begun to enter this field in a serious way. Expansion toward the creation of thoroughly fine things in this field would seem to be one of the real opportunities presented to industrial art in America.

A NEAR EAST POTTERY[1]

By Mabell S. C. Smith

The green and the deep blue of the unstirred sea and the brown of the plants that grow beneath the waters are poured over the graceful pieces of pottery that go by the name of "Kutahia." Sometimes a mere point of red suggests a hidden bit of coral. Over all slips the protecting glaze. The effect is cool, peaceful, very lovely. There is an effect of delicacy although the pottery is not light in weight.

Fig. 1.—An example of "Kutahia" pottery formerly made in Asia Minor now in Jerusalem.

The designs perpetuate ancient Armenian, Ottoman Greek, and Turkish patterns. So do the shapes. They are all thrown on the wheel and rise clearly and symmetrically to a perfect completion. There is great variety in them.

We Americans have a special interest in this ware because Near East Relief "ex-orphans" who have been maintained by American dollars and are now doing their best to be self-supporting are working in the pottery as apprentices. It is an appropriate place for them to be for the pottery used to be situated in the town of Kutahia in Asia Minor and belonged to Armenians and Ottoman Greeks. They were deported after the Smyrna disaster and the business had to be relocated. The clay in and about Jerusalem was similar to that at Kutahia and the new place has proved especially profitable because it is accessible to the tourists from all over the world who flock to the Holy City.

Fig. 2.—A Near East Relief orphan girl decorating pottery at the Jerusalem pottery.

Near East Relief trains all the 30,000 orphan boys and girls in its care in a craft or trade so that when they are old enough to leave the orphanages they will be able to support themselves. The occupations most in demand in the several localities where the orphanages are situated are those for which the children are educated, the building trades in Greece, for example, and agriculture in Armenia. According to this plan pottery work is exceedingly valuable to Palestine and the boys and girls engaged in learning the various aspects of the craft are being fitted into a lucrative and life-long business.

[1] Received Dec. 12, 1926.

Americans practicing the Golden Rule have been able to carry on the child welfare work in the Near East. The children value any opportunities that come to them to prove the gratitude they feel for

FIG. 3.—The head decorator of the pottery in Jerusalem teaching a class of Near East Relief orphan girls.

FIG. 4.—In the show room at the pottery in Jerusalem are Near East Relief boys arranging the Kutahia pottery.

now being able to live no longer in turmoil and distress but in the calmness and peace that is well symbolized by the cool and lovely coloring of the pottery of Kutahia.

NEAR EAST RELIEF
151 FIFTH AVE.
NEW YORK, N. Y.

PERMANENT EXHIBIT AT SOCIETY'S EXECUTIVE OFFICES CRYSTALLINE GLAZES CONE 11 PORCELAIN

The illustrations are of porcelain vases glazed at cone 11 designed and made by Frederick H. Rhead. They were presented to the SOCIETY as permanent exhibit by William McCoy, second vice president and general superintendent of the American Encaustic Tiling Co.

The SOCIETY has quite a collection of pottery, glass, and glass enameled wares. Those interested are urged to see this exhibit. It is not an antique collection nor is it modern; it contains representative pieces of several periods, but principally it is a collection showing different materials and processes.

FIG. 1.—Porcelain vase and base, 29 inches high. Cone 11, crystalline glaze.

FIG. 2.—Porcelain vase and base, 29 inches high. Cone 11, crystalline glaze.

Unique is the collection of defective glass. This defective glass exhibit was presented by D. J. McSwiney and Francis C. Flint. Informational exhibits like this one are valued as highly as exhibits of purely decorative and utility wares.

Members are requested to send in to the SOCIETY'S headquarters examples of ware defects, and to make additions to the exhibit of American utility and decorative wares.

The vases given by William McCoy of American Encaustic Tiling Co. are greatly appreciated. They show a very high order of craftsmanship and control at cone 11 on a commercial scale of body and glaze. They are 29 inches in height.

NEED FOR RESEARCH AND EDUCATION IN THE DINNERWARE BRANCH OF THE CERAMIC INDUSTRY[1]

By F. P. Judge, Jr.

It has often been said: "It is an ill wind that blows no one good" and when the recent world war retarded the wheels of industry in the belligerent countries the potters of the United States came into their own, for there came an unprecedented demand for dinnerware. Prior to this there was much apathy among many of our pottery manufacturers in the matter of improving their products, from the standpoint of appearance as well as durability.

When the demands were made to supplant wares that were heretofore imported it was brought forcibly to our attention by the dealers that we were not doing justice to ourselves as well as overlooking an opportunity to replace permanently a large percentage of the dinnerware that was imported if we did not take advantage of the situation and improve our products insofar as body, glaze, decorations, and shapes were concerned. Up to this time there were in the United States but very few potteries recognized as makers of fine dinnerware.

Ceramic Technologists Have Accomplished Many Things

Several manufacturers, sensing the opportunity at the time, set out to meet the demand for better dinnerware and the first thing they did was to employ the services of recognized leaders in the field of ceramic research. These ceramic engineers, handling that part of production for which they had been trained, soon made noticeable improvements in the appearance and serviceability of the wares made under their direction. Seeing what these manufacturers accomplished through their trained ceramists, other manufacturers did likewise and, as far as can be determined, those factories that are now making ware under the supervision of the trained ceramist are highly pleased with the product they are making. Each year sees an increase in the number of ceramic engineers doing the work for which they have fitted themselves.

Ceramic Art Is Needed

We recognize that bodies, glazes, firing, etc., are important features of our production and that a thorough knowledge of this phase of the business is essential to the successful conduct of our business. There is, however, another phase which must not be overlooked and that is the appearance of the

[1] Presented at the meeting of the Ohio Ceramic Industries Association, November 13, 1926.

finished product. A dinner set may be made of the finest materials and under the supervision of the best ceramic engineer in the country but if it is made without thought to attractiveness from the standpoint of shape and decoration then the work of the engineer is lost. The buying public today is more interested in the beauty of shape, decoration, and general appearance of the ware than they are in the fineness of the materials or the careful supervision under which the piece of ware is made. There is a need for the trained designer in this industry. For illustration: The furniture manufacturer, the makers of ladies' and gentlemen's clothing, the shoe manufacturer, the automobile maker, and so on, all have their trained experts whose sole duty it is to develop new styles from season to season or from year to year so that there is some inducement or reason for setting aside the furniture, clothing, shoes, or automobile that is not in style for that which is in the height of fashion. In the dinnerware business of this country I know of no one whose sole duty it is to create styles and it is my conviction that if this angle of the business was now developed as highly as it is in other lines the pottery industry of this State and of the country would be forging ahead instead of lagging as it now is. We might say that there are designers available and that the potters should be using them. We shall grant this but on account of their inexperience with ceramics the fruit of their creation is something that is impractical from the standpoint of manufacture.

"Ceramic art," both in theory and practice, unites a combination of qualities unknown in any other expression of human skill. No other industry presents so many diverse considerations, all of them of the utmost interest, and each one rich in economic and scientific application.

Finding its materials at the surface of the earth, pottery is easy to fabricate, and though fragile, of incomparable durability. The product of these substances, so simple in their character, so abundant and so easy to bring together, are absolutely endless in their variety, while in their most successful exponents their beauty may be pronounced matchless.

Coöperation of State University Needed

The ceramic schools of our country, especially the one of our own State, should have as part of their course of study a branch known as "Ceramic Art" which subject should cover designing and decorating. This part of the ceramic course of study should be treated from two angles: (1) The making of an article that is practical from the standpoint of manufacture. (Too often have we seen beautiful pieces of ware

designed, then found to be impractical when it came to manufacturing them.) The piece of ware designed should be created with the idea uppermost in mind that it can be made with a minimum of loss in the process of manufacture, economic from a kiln-placing standpoint and of such build that it will withstand the high temperatures of firing; (2) The piece of ware must have appeal from a consumer's standpoint, otherwise the designs would be valueless.

To get these practical angles of the study, part of the student's time should be spent in the factory. If this is done his ideas can be worked out in a practical manner instead of theoretically.

As said before, there is a need in our industry for trained workers of this kind. Our larger factories could regularly employ a designer of new products and decorations while our smaller factories, if they would only do it, could jointly in small groups keep a designer busy.

As one of the largest industrial units of this great State of Ohio, also as a group, among the heaviest tax payers the ceramic industry should have abundant coöperation from the State for the further advancement of our industry. If the State of Ohio is to maintain leadership in the ceramic industry our ceramic school should be adequately equipped and financed to carry on ceramic research and education in all its phases for the advancement of our industry. This Association should urge the State to appropriate sufficient funds each year to keep the ceramic department of this University the leading one of its kind in the world, also to work for the carrying of extension courses in ceramics to the ceramic centers of the State and the establishment and maintenance of an Experiment Station at the University where our manufacturers would be free to have their problems studied and recommendations made for the advancement of the industry. Those in charge of the ceramic division of this University are doing fine work with the limited facilities and funds available; however, their scope of study should be broadened and this can only be done by additional appropriations.

This Association should do all in its power to accomplish this purpose.

CREATED CERAMICS[1]

By Alfonzo Iannelli

Imagine yourself in a Spanish patio in the cool shade of palm trees with sun streaming on the garden wall, the flowers laid out in patterns to harmonize with the geometric plan, the shimmering tiles patterning the walls of blue, white, and green, all accentuating the coolness of the patio, in contrast with the extreme heat of the sun.

[1] Received September 30, 1926.

The effort to bring this coolness exercised the imagination of the artist creating tiles and from him came the results that fascinated the cavaliers and donnas of this charming land. As they sat and dreamed in these patios and perhaps listened to the music of guitar accompaniment, no small measure of delight must have come from the tile-lined rivulets which lead to the central fountain, also of colored tiles, which heightened the sparkle of the running water. The jars used by the Spaniards were equally as rich and inventive as their tiles. The frost-like decoration that adorned the surfaces of these vases of high glaze delighted the people as they touched them and filled them with flowers. These works in the hands of artists with imagination brought joy to the life of every onlooker.

This joy that they felt is the common effect of created art of all times and all places. All peoples have known and recognized this fact. The finely wrought Grecian vase lifted by the Greek maiden to pour water into a goblet for the master to drink must have given a zest to the function of both preparing the drink and to the drinker.

The Chinese, as lovers and artists of this material, have shown themselves to be extremely sensitive to the beauty of glazed clay, and in the works produced by the people bearing the character intrinsically their own, there is an appreciation that comes from within. The ceramic work of the Chinese is totally different in character from the work of the Spaniards or Greeks and yet it is definitely ceramic and has the nature of the material beautifully expressed. Seldom do we find in these people's expression in ceramics an effort to represent some other material. A piece of Greek sculpture cut in marble contrasted with a work of art made in clay shows a difference of materials that is quite marked.

Always the works of the great people, the works that we revere and recognize as beautiful, have been simply produced with a simple message, one understandable by the people for whom these works were made. The messages expressed were intimate and significant, not of another period or another age, but of their own age. The people responded to the works of art because they were made for their uses, and because in the decoration they could read a message that they knew and understood. It was, in a way, a personal delight that endeared these objects to them and made the owner proud to possess them.

If there is a law which is as unchanging as nature's law, it is that people naturally respond to a sincere effort, and they are moved by an expression which comes directly from the heart. In many cases the expression may be crude but it will be understood. According to my belief, the reason why ceramics has not been more thoroughy appre-

ciated here in America is because this material has not been in the hands of true creative artists who could give expression to the quality inherent in this material, but instead has been used by brokers for commercial use and for all the profitable returns it could bring. We need not despair, however, for the tendency is upward and we are getting better art in the clay products of this country now than we have for many years.

The technical processes have been perfected so that we can be assured of a fairly permanent product in this material, one that can withstand the elements. The material is sufficiently under control so that we may produce things of more artistic worth and we can give some attention to the spiritual message that is possible in ceramic work.

Naturally people have within them the urge and power for expression, if only they are given freedom and opportunity to express it. All that we humans express in work is the richness of our experiences and feelings. If there is beauty in life, this is expressed naturally by the people gifted in this field of expression.

We Americans live a truly romantic life; we live in a wonderful age, more moving and magic than has ever been known. In the fields of invention, we have achieved wonders in mechanics, and we have promoted business on a tremendous scale. If only a little of this same effort could be transmuted in our art, we would have in consequence as virile discoveries and results as we have achieved in the scientific fields.

In my observations, the reason why we are not further advanced in the arts is primarily because of the fear instilled in us, fear of our inability to produce works which compare with works of the Old World, so we hesitate to produce the new. Fundamentally people respond to and buy something they can understand. Products must sell in order that the factory may continue, but too often an ugly product sells because the market affords a limited choice. We are gradually educating ourselves in the appreciation and value of art.

Have you ever heard it said that the people must be given what they want? One instance that comes to my mind at the present, is the following: Some time ago I was called to design the interior of a radio station. At the conference held, three members of the radio concern were present trying to help me solve this interior. One of them thought that as their appeal was mostly to the farmer class they should like to see something of the farm character in this radio station. Another thought that the most appropriate expression would be early American and this would best be accomplished by having a colonial interior. The third member felt that the interior of a log cabin would be typical. The conference came to a close, and I was asked what I thought. Not

having anything to offer at that time, I asked that I might study the problem, it naturally being new to me. Two days later, I returned with a sketch, and on its presentation explained how I had arrived at the solution. I said that in considering the problem, I found that none of the suggestions offered seemed quite suitable. The problem of a radio station has nothing to do with early American or with the log cabin; radio is a magic force, modern, twentieth century; it moves rapidly. A message may be sent from one section of the globe to another and received instantaneously. This radio station should *express* a radio station. If the expression is a true one, all visitors will receive the impression of having seen a modern radio station. It met with the unanimous approval of the three members. This experience is typical of others I have had in different fields of endeavor, and proves to me beyond a doubt that fundamentally people respond to a natural and reasonable effort.

We should have in American ceramic work, the quality and character of twentieth century America expressing the beauty of its quick moving life with all its newness, (and its crudeness if that cannot be avoided) and freshness of its romance as long as it be natural.

We should have in the ceramic work a purity of expression and a message that you and I know; not the dance of Greek gods; we experience nothing through them, but the record of our feelings and emotions that are significant to us today.

I wish we could have in the plastic arts an expression that is as virile and natural as we have in our music.

It was my pleasure to experience the enthusiastic response and appreciation of Europeans towards American works in the fields of our real accomplishments, such as those mentioned heretofore, in the scientific fields, and in our music. This is the natural direction of modern life and their reverence for our achievements makes me realize that this is the quality we must introduce into our art.

In the European schools everything possible is done to encourage the appreciation of the living idea of today. It would be a beautiful experience for any American to suddenly see a bit of creative pottery that had a symbol of something reminiscent of the observer's own life. This would cause him to meditate in delight and, in consequence, appreciate and buy.

Park Ridge, Illinois

ACTIVITIES OF THE SOCIETY

OUR MEMBERSHIP ROSTER

This SOCIETY is growing in strength and in service. Growth of the SOCIETY is gaged by increase in interest on the part of the individual members, and the increase in interest has followed a realization of the value which is accruing and the greater value which is possible through more active participation by individuals and through larger facilities.

The things accomplished in 1926 are recorded in part in the 1926 monthly *Journal*. Results of the work of the committees have not been reported but are being made indirectly evident in the larger number of original papers published, and in the more thorough abstracting of the world's literature and in the bibliographies published and in preparation.

You wish a larger return from your membership. You can have it if you will pull a little more consistently and if you will get the aid of others. A larger membership roster is desired not primarily to increase the SOCIETY'S financial resources but to more effectively and speedily make advances in the arts and science of ceramics. The larger the number of persons collaborating in this SOCIETY the larger will be the returns had by the individual members and by the supporting corporations.

Get more members if you want more for your ten dollars.

MEMBERSHIP RECORD FOR 1926

	Personal			Corporaton		
	1924	1925	1926	1924	1925	1926
January	31	24	26	6	1	2
February	40	19	37	8	2	7
March	29	35	62	–	6	8
April	35	9	15	3	1	3
May	25	15	11	4	3	3
June	18	15	11	2	2	3
July	14	15	13	3	–	–
August	9	12	5	–	1	–
September	9	9	5	–	2	–
October	17	14	15	2	1	2
November	11	26	18	2	3	1
December	11	—	19	–	–	5
Total	249	193	237	30	22	34

Membership Workers' Record for 1926

From Nov. 16, 1925 to Nov. 16, 1926

P=Personal Membership.
C=Corporation Membership

F. E. Allen, 2 P.
A. I. Andrews, 3 P.
Mrs. J. F. Baccus, 1 P.
C. E. Bales, 2 P.
L. E. Barringer, 1 P.
M. F. Beecher, 1 P.
H. T. Bellamy, 1 P.
C. F. Binns, 1 P.
M. C. Booze, 1 P.
H. H. Blau, 2 P., 1 C.
A. V. Bleininger, 1 P.
J. E. Brinckerhoff, 2 P.
Davis Brown, 1 P.
R. B. Carothers, 1 C.
K. H. Chu, 1 P.
H. T. Coss, 2 P.
Paul E. Cox, 1 P.
G. W. Cronquist, 1 P.
E. deF. Curtis, 1 P.
H. L. Dixon, 1 P.
W. B. Ebert, 1 P.
E. A. Eigenbrot, 1 P.
K. H. Endell, 1 P.
H. R. Feichter, 1 P.
Ferro Enameling Co., 4 P.
W. C. Fisk, 2 P.
M. L. Fosdick, 1 P.
H. D. Foster, 1 P.
H. Frechette, 1 P.
M. M. French, 2 P.
C. E. Fulton, 1 P.
C. F. Geiger, 6 P.
A. F. Greaves-Walker, 1 P.
R. A. Hand, 1 P.
M. L. Hartmann, 1 P.
F. T. Heath, 1 C.
P. D. Helser, 2 P.
A. V. Henry, 2 P.
L. C. Hewitt, 1 P., 1 C.
M. E. Holmes, 1 C.
B. M. Hood, 2 C.
R. A. Horning, 7 P.
M. R. Hornung, 1 P.
H. S. Housman, 1 P.
J. T. Howington, 1 P.
R. K. Hursh, 3 P.
M. Ichijo, 1 P.
H. J. Knollman, 4 P.
A. H. Kuechler, 1 P.
R. D. Landrum, 1 C.
S. J. McDowell, 1 P.
T. N. McVay, 8 P.
A. Malinovszky, 1 P.
W. Malsch, 2 P.
P. Marson, 1 P.
O. E. Mathiasen, 2 P.
R. J. Montgomery 2 P., 1 C.
A. N. Outzen, 2 P.
F. T. Owens, 1 P.
C. W. Parmelee, 3 P.
H. A. Plusch, 2 C.
E. P. Poste, 1 C.
A. Powell, 1 P.
W. A. Preische, 3 P.
W. D. Richardson, 1 P.
F. H. Riddle, 1 P.
R. Rieke, 1 P.
F. W. Rogers, 1 C.
Samuel Rusoff, 1 P.
W. L. Sample 1 P.
S. Satoh, 1 P.
C. W. Saxe, 1 P.
C. Saxton, 1 C.
W. J. Scott, 1 P.
W. L. Shearer, 6 P.
Mary G. Sheerer, 1 P.
A. Silverman, 3 P.
J. L. Silvers, 1 C.
G. Simcoe, 1 P.
P. A. Smith, 1 C.
F. Stanger, 1 P.
A. Stein, 1 P.
W. J. Stephani, 1 P.
H. R. Straight, 3 P.
E. B. Streater, 1 P.
C. F. Tefft, 1 P.
F. M. Thorman, 1 P.
C. Tillotson, 1 P.
E. W. Tillotson, 1 P., 1 C.
W. E. S. Turner, 2 P.
R. Twells, 2 P.
E. J. Vachuska, 1 P.
W. H. Vaughn, 2 P.
A. S. Watts, 4 P.
H. Wilson, 4 P.
H. G. Wolfram, 1 P.
W. G. Worcester, 1 P.
W. H. Zimmer, 2 P.
A. S. Zopfi, 1 P.

NEW MEMBERS RECEIVED FROM NOVEMBER 15 TO DECEMBER 16,

Horace W. Alexander, student, 412 E. Green St., Champaign, Ill.

Rebecca G. Allen, 132 Marlborough St., Boston, Mass.

Oscar L. Bachelder, Potter, Owner, Omar Khayyam Pottery, Candler, N. Car.

H. G. Blakeslee, Vice Pres. & Asst. Genl. Mgr.; Airkool Spark Plug Corp., 1089 Peachtree St., Atlanta, Ga.

Russell G. Crook, Sculptor, South Lincoln, Mass.

Ellen W. Cushing, 138 Marlboro St., Master Craftsman of the Society of Arts and Crafts, Boston, Mass.

George F. Frederick, Instructor of Pottery, School of Industrial Arts, 13 Willow St., Trenton, N. J.

Clifford C. Goodson, Production Mgr., Calif. Clay Products Co., 314 S. Santa Fe Ave., Huntington Park, Calif.

John H. Grady, student, 108 W. Woodruff Ave., Columbus, Ohio.

Geo. D. Haines, Vice Pres. & Gen. Mgr. Knapp-Haines Co., Inc., 602 Fairview Ave., Park Ridge, Ill.

Edward S. Hanson, Mgr., "The Ceramic Age," 124 N. 7th St., Newark, N. J.
Carl R. L. Hilgenberg, student, Room 103–1901 Hall, Princeton, N. J.
Melvin M. King, Chemist, R. I. Division Corning Glass Works, Central Falls, R. I.
Geo. R. Kiser, student, 116 Hyland Ave., Ames, Iowa.
Catherine M. Neuwiesinger, Asst. Prof. of Art, Alabama College, Montevallo, Alabama.
Thad O. Smith, Kansas City Terra Cotta & Faience Co., 1809 Manchester Ave., Kansas City, Mo.
Erwin Sohn, Director of Research, Standard Sanitary Mfg. Co., 11 Ontario St., Oak Park, Ill.
Jaroslav J. Svec, student, 61 E. Green St., Champaign, Ill.
Leon Volkmar, Prof. of Art, 3427 Cornell Place, Clifton, Cincinnati, Ohio.
David C. Zimmer, student, 1927 Waldeck Ave., Columbus, Ohio.

Membership Workers' Record

	Personal		Personal
L. R. W. Allison	1	J. C. Hostetter	1
A. I. Andrews	2	Clarence B. McComas	1
Paul E. Cox	1	S. J. McDowell	1
E. deF. Curtis	5	W. J. Stephani	1
A. F. Greaves-Walker	1	Office	6
		Total	20

NEWS FROM MEMBERS OF THE SOCIETY

L. B. Bassett has moved from Winchedon, Mass., to Westerly, R. I.

Laurence H. Brown, who has been situated in the Research Dept., Buffalo Pottery, Buffalo, N. Y. has accepted a position with the Orlando Potteries, Orlando, Fla.

Marsden H. Hunt has moved from Oakland, Calif., to Derry, Pa.

R. M. King, recently of St. Louis, has notified the Secretary that his present address is P. O. Box 561, Coatesville, Pa.

C. C. Leigh has moved from Columbus, Ohio, to Chicago, Ill.

Theodore Lenchner, formerly with Vitro Mfg. Co., has recently become associated with Roessler and Hasslacher.

L. W. Mercer has been appointed corporation representative for the Square D Company, Peru, Ind., to succeed A. P. Ball, who recently severed his connections with that Company.

A. R. Payne has removed from Clarksburg, W. Va., to Moundsville, W. Va., where he is now associated with the Fostoria Glass Co.

A. H. Sheffield, formerly Secretary of the American Terra Cotta and Ceramic Company, has moved to Kansas City, Mo., where he is Vice President and General Manager of the Kansas City Terra Cotta and Faience Company.

C. C. Vogt, of Mellon Institute, has accepted a position with the Armstrong Cork and Insulation Company, Argo Laboratory, Gloucester, N. J.

D. C. Wysor is now located with the General Chemical Company, Monarat, Carroll County, Virginia.

NOTES AND NEWS

OFFICERS OF OHIO CERAMIC INDUSTRIES ASSOCIATION

In the preliminary organization work, yeoman services were rendered by Thomas B. Anderson of the Pope Gosser China Co. and W. Keith

McAfee of the Cambridge Sanitary Manufacturing Co. as president and secretary respectively of the Ohio Ceramic Industries Association. These two with a loyal executive committee gave many hours to launching the several educational and research plans sponsored by the Association. (1) A high school course in ceramics at East Liverpool with plans developing for others throughout the State, (2) a ceramic division in the Engineering Experiment Station at Ohio State University with a full time research professor in charge, (3) a ceramic art technology course in the Fine Arts College, and (4) an experimental plant in conjunction with the prison operated brick plant at Roseville, both plants under technical supervision of the ceramic research professor of the Experiment Station, are well along to full realization.

T. B. ANDERSON

While these projects were being moved along to full establishment, J. L. Murphy of the Nelsonville Brick Co. saw their import to the future ceramic welfare of the State and not only gave aid unstintingly with time and money but secured unanimous support of the other brick manufacturers.

J. L. MURPHY

At the annual meeting last month Mr. Murphy was elected President of the Ohio Ceramic Industries Association, and George A. Bole, research professor and Secretary of the Association, W. K. McAfee, Vice President, and C. B. Harrop, Treasurer.

Photo likenesses of Messrs. Anderson and Murphy are here shown as a first time introduction of them to the readers of the *Journal*. The other officers and committeemen of the Ohio Association are known to our readers by photographs and by their works.

DEATH OF WALTER S. KUPFER

The death of Walter S. Kupfer, president of the American Dressler Tunnel Kilns, Inc., occurred on November 25, 1926. Mr. Kupfer played a great part in introducing the tunnel kiln to the United States, and by personal efforts assisted in bringing it to the present point of universal acceptance as the logical and best method of dealing with most firing operations.

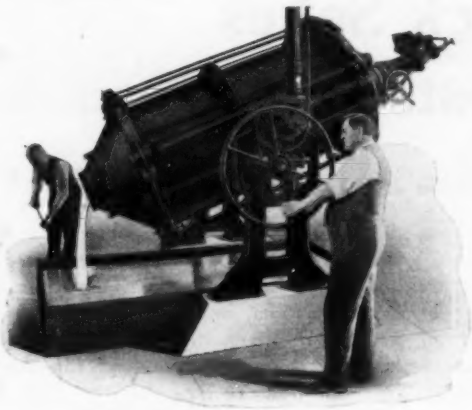
Mr. Kupfer first became interested in the Dressler Tunnel Kiln in the spring of 1915 when the first kiln was installed in the plant of the Universal Sanitary Mfg. Co., New Castle, Pa., of which he was part owner. The American Dressler Tunnel Kilns, Inc., was incorporated by him in the summer of 1915.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb. 14–19, 1927	Detroit, Mich.
Amer. Assn. Advancement of Sci.	Dec. 27, 1926–Jan. 1, 1927	Philadelphia, Pa.
American Chemical Society	April 11–16, 1927	Richmond, Va.
Amer. Concrete Institute	Feb. 22–24, 1927	Chicago, Ill.
American Concrete Pipe Assn.	Feb. 21–22, 1927	Chicago, Ill.
Amer. Electrotechnical Soc.	April 28–30, 1927	Philadelphia, Pa.
Amer. Engineering Council	Jan. 13–15, 1927	Washington, D. C.
Amer. Gas Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Chem. Engrs.	June 1–4, 1927	Cleveland, Ohio
Amer. Inst. Min. and Met. Engrs.	Feb. 14–17, 1927	New York City
Amer. Soc. Mech. Engrs.	May 23–26, 1927	White Sulphur Springs, W. Va.
Amer. Soc. Steel Treating	Sept. 19–23, 1927	Detroit, Mich.
Amer. Soc. Testing Materials	June 20–24, 1927	French Lick, Ind.
Amer. Zinc Institute	April 18–19, 1927	Montreal, Canada
Assn. Chem. Equipment Mfrs.	Sept., 1927	New York City
Can. Natl. Clay Prod. Assn.	Feb. 8–9, 1927	Toronto, Canada
Common Brick Mfrs. Assn.	Feb. 21–26, 1927	Chicago, Ill.
Eastern Clay Products Assn.	Jan. 11, 1927	Pittsburgh, Pa.
Glass Container Assn.	April or May, 1927	?
Hollow Bldg. Tile Assn.	Feb. 9–11, 1927	Chicago, Ill.
Manufacturing Chemists Assn.	June 2, 1927	New York City
Mining and Met. Soc. of Amer.	Jan. 11, 1927	New York City
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 8, 1927	Pittsburgh, Pa.
Natl. Assn. of Stove Mfrs.	May 11–12, 1927	New York City
Natl. Brick Mfrs. Assn.	Jan. 12–13, 1927	Columbus, Ohio
Natl. Safety Council	Sept. 26–30, 1927	Chicago, Ill.
Natural Gas Assn. of Amer.	May 17–19, 1927	Cincinnati, Ohio
Sand-Lime Brick Assn.	Feb. 1–3, 1927	Detroit, Mich.
Society of Glass Technology	Jan. 19, 1927	Manchester, Eng.
(Eng.)	Feb. 16, 1927	Sheffield, England
Stained Glass Assn. of Amer.	June 27, 1927	St. Louis, Mo.

U. S. Rotary Enamel Smelting Furnaces Give

SATISFACTION



Excellent Results Best Demonstrated by Large Number of Repeat Orders

Crane Enamelware Company, Chattanooga, Tennessee.
Kohler Company, Kohler, Wisconsin.
Porcelain Enamel & Mfg. Company, Baltimore, Md.
Ingram-Richardson Mfg. Company, Frankfort, Ind.
Ingram-Richardson Mfg. Company, Beaver Falls, Pa.
Ingram-Richardson Corporation, Bayonne, N. J.
Grand Rapids Refrigerator Co., Grand Rapids, Mich.
Columbian Enameling & Stamping Co., Terre Haute, Ind.
Sheet Metal Products Company, Toronto, Canada.
Republic Metalware Company, Buffalo, N. Y.
Pacific Sanitary Mfg. Company, Richmond, California.
A. Weiskittel & Son Company, Baltimore, Md.
Malleable Iron Range Company, Beaver Dam, Wis.
Edison Electric Appliance Co., Inc., Chicago, Ill.
Welsh Tinplate & Metal Stpg. Co., Ltd., Llanelly, England.
Ernest Stevens, Limited, Cradley Heath, England.
Ward Leonard Electric Company, Mount Vernon, N. Y.
American Enameled Products Co., Chicago, Ill.
Michigan Porcelain Tile Works, Ionia, Michigan.
Stanley Insulating Company, Great Barrington, Mass.
Roesch Enamel Range Company, Belleville, Ill.
L. D. Caulk Company, Milford, Delaware.

SIZES AND CAPACITIES

No. 1	No. 2	No. 3	No. 4	No. 4-B
60 lb.	150 lb.	350 lb.	750 lb.	1200 lb.

Description, Photographs, Specifications and Prices Mailed Promptly

THE U. S. SMELTING FURNACE CO.

BELLEVILLE. ILLINOIS, U. S. A.

Light Weight of Georgia Kaolin Brick Saves Freight Costs

Extract from Bulletin 252, U. S. Bureau of Mines

"The average weight of several standard sized kaolin fire brick was 6½ lbs., as compared to 7 lbs., average weight of standard sized fire-clay fire brick. The difference of a half pound in weight per brick, therefore, means a saving of 500 lbs. per thousand, an item which comparatively reduces freight cost materially.

"Every ton saved in the refractories for boiler settings in naval craft and ocean-going liners means a ton increase in displacement for ammunition, fuel, or freight."

The supply of raw material in Georgia is almost inexhaustible. Deposits, mainly surface, cover an area of approximately 10,000 square miles, and practically all of this vast deposit can be mined by stripping with steam shovels and delivered to the plant at 40 to 50 cents a ton. The same clay is used as a grog or bond, thus eliminating the necessity of hauling one or more materials from distant points—a great economic factor.

Power rates are low, fuel is cheap, and there is a good supply of intelligent labor. Freight rates, both water and rail, are favorable. A plant shipping by water from Savannah can reach the North Atlantic ports at less cost than brick can be freighted for from Pennsylvania or states west.

Reports on tests made and bulletins describing the deposits along the Central of Georgia Railway may be had for the asking. The Central of Georgia Railway will furthermore give every possible assistance to prospective manufacturers.

The Central of Georgia Railway has made a comprehensive survey of the vast clay deposits of the Coastal Plain of Georgia and Alabama and is in a position to furnish valuable information and suggestions to those interested in the manufacture of fire brick or otherwise interested in mineral and chemical enterprises.

CENTRAL OF GEORGIA RAILWAY

Industrial Department

J. M. MALLORY,
General Industrial Agent

413 West Liberty Street,
Savannah, Ga.

BUYERS' GUIDE

A

Agitators
Cain Machine Co.

Alumina (Hydrate and Calcined)
Harshaw, Fuller & Goodwin Co.
Pennsylvania Salt Mfg. Co.
Roessler and Hasslacher Chemical Co.

Aloxite (Refractory Products)
The Carborundum Co.

Alundum (Refractory Products)
Norton Co.

Auger Machines
Chambers Brothers Co.

Automatic Brick Machinery
Lancaster Iron Works, Inc.

Automatic Cutters
Chambers Brothers Co.

Automatic Stove Rooms
Philadelphia Drying Machinery Co.

Automatic Temperature Control
Leeds & Northrup Co.

B

Balls (Mill)

Ball Mills
McDaniel Refrac. Porcelain Co.
Mueller Machine Co., Inc.

Batts
The Carborundum Co. *("Carbofrax Aloxite")*
Norton Co. *("Alundum-Crystolon")*

Bench Whirlers
Cain Machine Co.

Bitstone
Eureka Flint and Spar Co.
Potters Supply Co.

Bituminous Coal
Seaboard Fuel Corp.

Blocks (Refractory)
The Carborundum Co.
Norton Co.
The Chas. Taylor Sons Co.

Blunger Mills
Cain Machine Co.

Boats, Combustion
Norton Co.

Borax
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Innis Speiden & Co.

Boric Acid (Crystal, Granular or Powder)
American Potash & Chemical Co.
Drakenfeld & Co., B. F.
Innis Speiden & Co.

Brick (Porcelain)

Brick Making Machinery
Chambers Brothers Co.

Bricks (Refractory)
The Carborundum Co. *("Carbofrax Aloxite")*
Harbison Walker Refractories Co.
Norton Co. *("Alundum-Crystolon")*
The Chas. Taylor Sons Co.

Burners (Oil)
Best, W. N. Corp.

COAL FACTS

Potters & Ceramists

we extend to you

Best Wishes for a

HAPPY and PROSPEROUS

NEW YEAR

1927

May new business and repeat orders be yours in abundance,—and may you continuously take a *High Percentage of "Good Ware" from your Kilns.

NOTE—

*This can be assured by the use of—

Seaboard Kiln Coals

260 South Broad St. Philadelphia

No. 1 Broadway New York City

BUYERS' GUIDE (continued)

C

Cars (Clay)
Lancaster Iron Works, Inc.

Carbofrax (Refractory Products)
The Carborundum Co.

Carbonates (Barium-Lead)
Innis, Speiden & Co.

Caustic Soda
Pennsylvania Salt Mfg. Co.

Cements
The Carborundum Co.
Norton Co.

Ceramic Chemicals
Drakenfeld and Co., B. F.
Harshaw, Fuller & Goodwin Co.
Metal & Thermit Corp.
Paper Makers Importing Co. (Inc.)
Roessler and Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
Vitro Mfg. Co.

Ceramic Plant Equipment
Chambers Brothers Co.
Mueller Machine Co., Inc.
Philadelphia Drying Machinery Co.
Proctor and Schwartz, Inc.

Clay (Ball)
Harshaw, Fuller & Goodwin Co.
Kentucky Construction & Improvement Co.
Paper Makers Importing Co.
Potters Supply Co.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (China)
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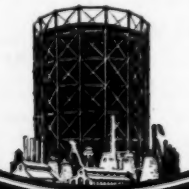

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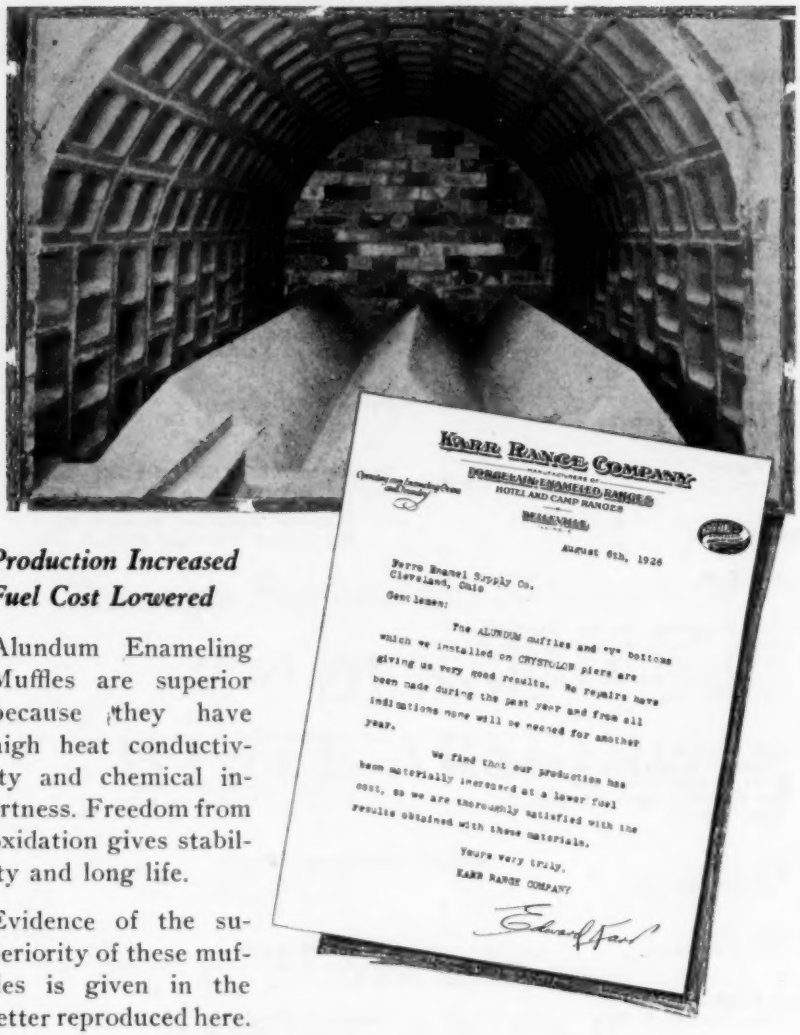
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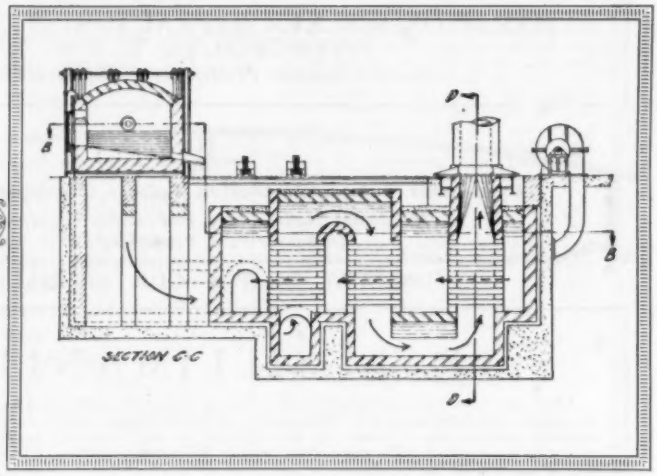

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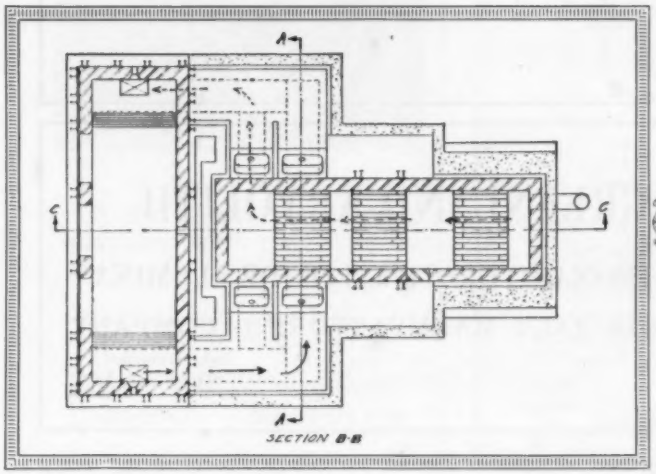

In the new recuperator "corebusters" are employed in the Carbofrax Tubes to compel the air to pass in contact with the heated walls of the tubes thus materially increasing the heat transfer from hot waste gases to combustion air.

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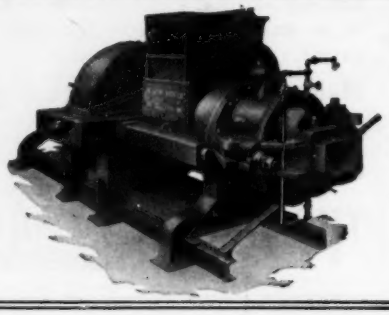

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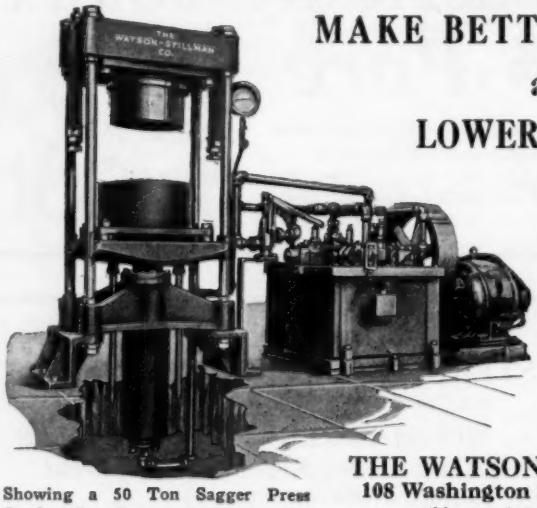

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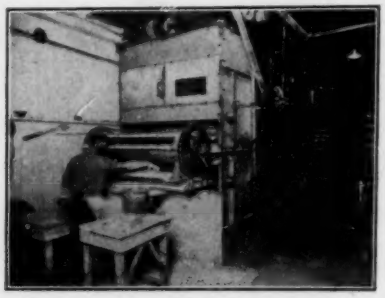

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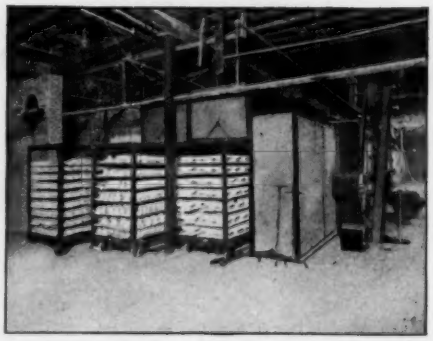

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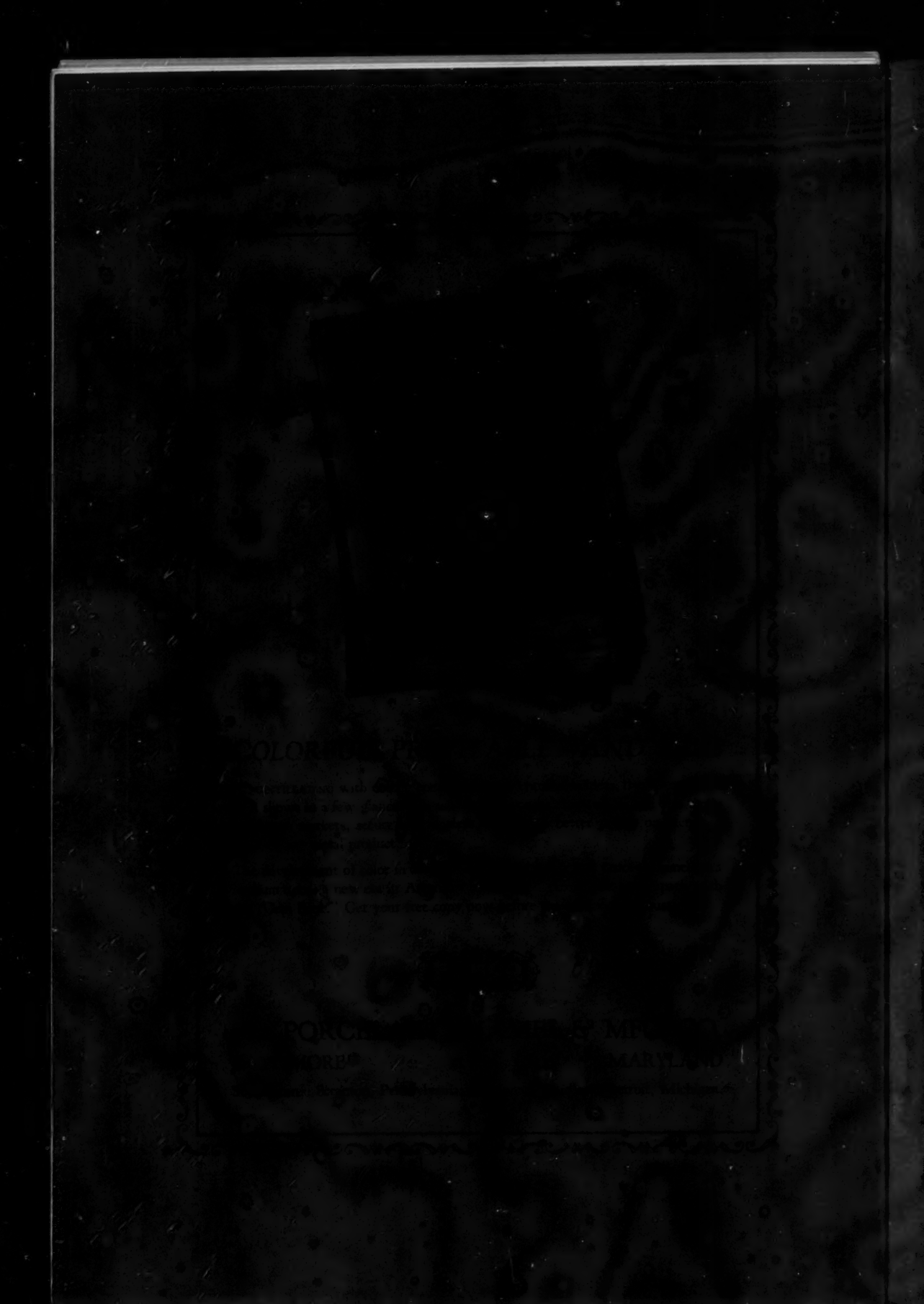
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